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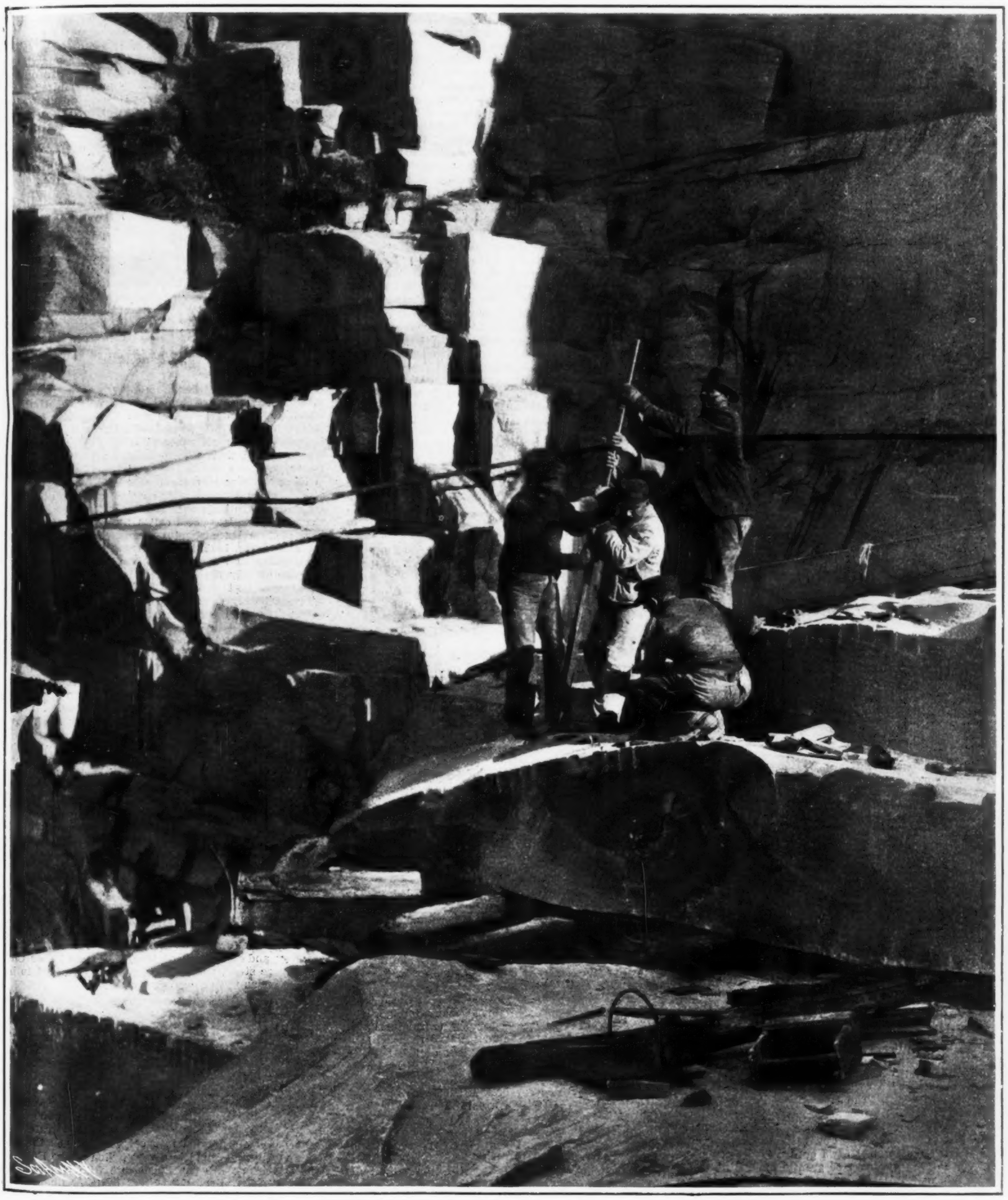


A SCENE IN A GRANITE QUARRY.

GRANITE QUARRIES.

Quarrying is unquestionably one of the very early steps in the development of human culture, and the stone age, the earliest recognized stage in the progress of civilization, is that period when man first began to supplement the implements afforded him by nature by fashioning crude, artificial weapons and utensils. Beyond doubt there existed prior to the stone age a period when man employed exclusively more perishable material, such as wood, but we are absolutely without knowledge of it, for while these ages are defined by the prevailing material of the relics, rather than by the actual implements then in common use, we can but conjecture the state of cultural development during that vague period between the indefinite beginning of the age of stone and the time of primitive man's emergence from the anthropoid ape. In the beginning of the stone age man certainly contented himself with the use of bits of stone such as adaptably shaped, water-worn rocks; but it is not a far cry from gathering loose stones to loosening others from the greater masses, and to this we may ascribe the beginnings of the quarry. The science of quarrying advanced rapidly, especially after the introduction of the metals, and that, in fact, it outdistanced the metallurgical arts, is evidenced by the historic ruins still existent and containing those vast monolithic blocks, columns, and ornaments, unparalleled even to-day, which were carved out of the living rock by the hands of men whose civilization arose, flourished, and passed away scores of centuries before the Christian era.

The beginning of quarrying in America was to all intents and purposes coincidental with the settling of the country, and it is probable that many, even of the very early pioneers, cut and roughly shaped hearthstones and door-sills of stone for their cabins. It was not till much later, however, that the industry began to assume anything like the importance which it now holds. Granite quarrying, the subject of the accompanying illustration, was begun on a large scale in the United States at Quincy, Mass., in 1820, and since that time New England has been the principal granite-producing section of the country, Maine leading the individual States. The industry developed gradually but steadily, owing to the low freight rates by water, and to-day the value of the stone of all kinds produced annually for structural and ornamental purposes is nearly seventy million dollars. In the old days the labor of quarrying was all done by hand, but at the present time steam or compressed air gadding-drills largely take the place of wedge and sledge hammer, and the steam derrick, electric hoist, and crane have generally supplanted the old horse-sweep for lifting the blocks from the quarry. Improved pneumatic shaping and pointing machinery and polishing apparatus have also long been in use. Paradoxical as it may seem, the introduction of modern machinery has not altered the underlying fundamental methods used in quarrying and preparing the material; and so, for instance, while the artisan formerly "finished" a stone by rubbing it painstakingly with some polishing substance, to-day this is performed by a machine which practically does nothing more than substitute an arm of iron for the human member, and which executes practically the same motions in the same manner as the other.

The photograph illustrates the method of removing a large block from the parent mass. The stratification of the granite is used to advantage in obviating undercutting of the stone. A stratum of proper thickness for the required block is chosen, and then the section is loosened by making vertical cuts extending from one horizontal seam to the next below. Sometimes the cuts do not extend entirely through the stratum, and in this case the block is riven from the ledge by means of wedges and hammers. The cuts are made by drilling a series of circular holes, about two inches in diameter, close together, and then joining these with a connecting cut. The drills are of the usual steam type, but in order to avoid the necessity of setting up the machine for each hole, it is suitably mounted on a long steel rod, along which it can easily be moved from point to point as required. Very little blasting is made use of, as this operation is extremely liable to injure the granite.

After the block is loosened it is removed to the side of the quarry and roughly split into the shape desired. Lines are marked upon the surface of the stone, and a series of holes drilled into it along this marking. Two flat, thin strips of iron are inserted into each hole, and the protruding ends bent outwardly to prevent the strips from entering too far. An ordinary iron wedge of suitable shape is inserted between each pair of the strips, which are used to prevent the edges of the hole from chipping as the wedges are driven in. The tightening of the latter is executed as uniformly as possible, and if properly done the granite will split smoothly unless it contains faults. If flat slabs, too narrow to be obtained by the wedging process, are desired, a sawing operation is resorted to. The saw is not of the usual type, but consists of a flat bar of soft iron, which is notched by a series of drill-holes just intersecting the lower edge. The saw is fed downward, and as the cut progresses water and coarse emery are introduced from above through a sort of clay funnel plastered onto the stone. For certain varieties of softer stone, circular steel saws or diamond saws are employed, but the hardness of granite makes the use of these impracticable here.

The next operation after the block has been approximately split or sawn into shape is called pointing. The operation consists in smoothing down the surfaces to the exact shape and dimensions outlined, by means of pneumatic tools of various sorts and shapes, depending on the character of the surface desired. These grinding tools are so mounted upon a movable arm that they can be easily shifted in all directions by the workmen engaged in the operation. The machine is not unlike, in certain respects, the ordinary dentist's drill.

When the final shaping is completed, the stone is polished according to the purpose for which it is intended. For flat surfaces a machine is used in which a revolving iron plate or grating is attached to the lower end of a vertical shaft. The shaft is so arranged that it can be moved about freely, the workmen guiding the polishing plate to various parts of the surface. The latter is inclosed in a framework or rim of wood made water-tight by means of plaster of Paris, so that the water and abrading material which is constantly fed onto the surface may not escape. In the first polishing, a flat plate is used, with water and emery or corundum powder. In the second operation the plate is replaced by a series of flat concentric rings held in their relative positions by radial ribs, and the water and abrading substance, finer than in the first polishing, are fed in between the rings. In the final operation a felt-covered plate is used with pumice stone and polishing putty or oxide of tin. Small blocks are often ground, first with wet sand and then with finer material upon a revolving iron bed-plate. Pendulum machines are used for polishing simple moldings, which are first cut as smoothly as possible with the chisel. A plate of cast iron, fitted as accurately as possible, is made, by means of a long arm, to travel back and forth along the molding with water and an abrasive. Where it is not possible to use a machine, granite is polished by hand with water, polishing material, and a small piece of similar stone presenting a finished surface.

The turning of a column in a lathe is a method entirely analogous, with the exception of the form of cutting tools, to the one used in metal work. The cutter consists of a steel disk 6 to 8 inches in diameter, mounted rotatably on a shaft and presenting a sharp beveled edge. The shaft of the disk lies in the same plane as the center line of the object turned, but at a sharp angle with it. The disk revolves with the stone against the shoulder of the cut, which is small and is made at a slow rate of speed. The edge wears off very rapidly, and the disks must be frequently replaced. To-day, pneumatic tools are used almost exclusively in cutting ornamental stonework, though chisels and hammers are still essential for certain portions of the work.

PRECIOUS STONES IN 1904.*

By George F. Kunz.

The important facts in the history of precious stones in 1904 are in the main as follows:

The output of diamonds was less in quantity than in 1903, and the year was marked by several advances of 5 per cent in the price of the rough-diamond material, which was imported into the United States to the value of $9,675,742, from which it would appear that diamonds and pearls to a greater value are now cut annually in the United States than were imported, cut or uncut, into the country for the years 1867 to 1871, inclusive, or for any one year until 1887. The value of the total import of precious stones for the year was $26,086,813.

The cutting strikes in Amsterdam, which were of long duration and threatened to be so disastrous to the diamond trade, are apparently settled for a period of at least three or four years to come.

The greatest diamond known in history (prior to 1905), the "Excelsior" of Jagersfontein, has been cut up and divided into ten stones, weighing from 13¾ to 68 carats each, and furnishing a total of 340 17-32 carats of the whitest material of any of the large diamonds, with a total value of about $400,000.

No great diamond discoveries abroad were chronicled during 1904, but the development of the mines in the Transvaal has been remarkable, the new Premier having produced diamonds to a total of 749,653 carats, valued at $4,201,000, during the year, and promising to become a still greater factor in production. In the case of this mine, 60 per cent of the output is controlled by the Transvaal government.

No discoveries of diamonds were recorded in the United States during the year 1904.

In Brazil a number of attempts were made to form new diamond mining companies, but the output has been very small.

In British Guiana the interest is still maintained, and the production was about the same as in the preceding year.

It is a fact of especial interest that in the cutting of gems other than the diamond many foreign lapidaries have entirely discarded emery (corundum) and are substituting for it the artificial carbon silicide, carborundum, which has a hardness of 9.5, between corundum (9) and diamond (10), and is the best-known abrasive next to the diamond. The year 1904 also witnessed the first discovery of this substance as a natural mineral in the Canyon Diablo meteorite by Prof. Henri Moissan, of Paris, France, and the naming of it after him, *moissanite*, as a true mineral, by the writer.

Australian sapphires, from the Anakie district of New South Wales, which are frequently too dark for high-grade stones, were cut in quantities in both faceted and unfaceted forms and *en cabochon* and used for the medium quality of jewelry.

In the United States one gem discovery after another has been made in southern California, notably in San Diego County, where there have been found magnificent blue and white topazes, near Ramona, which as crystals quite equal those from Siberia, a single one weighing more than a pound; beryls from 3 to 6 inches in length and 1 or more inches in diameter, pale to dark sea green in color; crystals of rose-colored beryl, until recently one of the rarest varieties of this mineral, at Mesa Grande and Pala (and also at Hemet, in Riverside County); axinite, a gem mineral not previously known in good crystals in this country, though formerly in Switzerland and France, in beautiful crystals, near Bonsall; colored tourmalines, red and green, have been extensively mined at Mesa Grande, Pala, and other localities in the same county; and epidote in crystals only 1 inch in length and one-eighth of an inch in diameter, but transparent, has been found near Hemet, in Riverside County. The old locality at Mount Mica, Paris, Me., has produced fine tourmaline crystals and some good gems; a new locality, also interesting for its crystals of tourmaline, which are large and beautiful, although of little gem value, has been opened near Rumford Falls, Me., and some very fine crystals have been found at the mine at Haddam Neck, Conn. Kunzite, the new gem spodumene, has been mined, but not so extensively. As to sapphires, the entire output and also all previous outputs of those found at Yogo Gulch, Mont., have been disposed of abroad up to the present time by the companies which operate these mines from London. Turquoise has been mined with some success at a number of localities in New Mexico, Arizona, Nevada, and California. The new locality for peridot, olivine, or chrysolite, as it is variously known, at Talklai, Gila County, Ariz., has yielded great quantities of this mineral, immediately associated with or inclosed in the volcanic rocks; thousands of beautiful gems of from 1 to 5 carats have been cut from this material and extensively sold throughout the United States.

Great development has taken place in gem production in Brazil. Continued exploration in the State of Minas Geraes has led to great discoveries of tourmaline, which have furnished magnificent red (rubellites), as well as blue-green, and green gems; and large quantities were found, cut and sold during 1904. Further discoveries of gem beryls in the same state have furnished magnificent blue and green aquamarines, which have been cut and have reached the gem markets of the world.

In regard to the Brazilian amethyst, a large quantity of gems have come from the great geode, the bulk of which was shown at the Düsseldorf Exposition in 1902. Many of these which were obtained from the points of the myriads of crystals that lined the great grotto were, on account of their rich, dark color, sold as Siberian amethyst.

There has been an extensive demand for many of the semi-precious stones, such as the peridot, of which quantities have been cut from Egyptian material, and the yellow smoky quartz called topaz from Spain and Brazil. The Queensland opal matrix has also been much in favor, both the variety with rich patches of opal, either white or bluish, often of great brilliancy, and the variety that is dark brown, with the entire mass permeated with very thin irregular streaks or veins of highly colored opal, making a perfectly iridescent play of color on a brown field, like the lumachelle marble.

Semi-precious stone beads of every variety of material, in short and long necklaces and of all sizes, either round, India cut, or faceted, made of amethyst, Spanish topaz, rock crystal, rose quartz, aventurine, blue chalcedony, amazon stone, New Zealand jade (nephrite), Burmese (so-called Chinese) jadeite, moonstone, garnet, and other minerals of every kind, have been sold in great profusion.

Coral has been greatly in vogue, especially in the form of beads, often of great size. The market has demanded the richest Mediterranean coral, either deep red or delicate pink; Japanese coral, pink, yellow pink, and red; as well as white coral, either pure white or with a single speck of red or pink on each bead, the beads in the center of a string being often ¾ of an inch to 1 inch in diameter. The demand and the high price for the pale-pink coral has led to some imitations, consisting, first, of a decoloration of the darker coral by heating; second, of marble of about the same weight as coral and stained with aniline or other dyes; third, of white coral stained in the same manner; and, fourth, of glass paste imitations imported from the East. Another imitation is made from the mineral substance so much used by the Chinese for their stone carvings and imitations of jade, agal-matolite or Chinese figure stone, which is very cleverly stained to be palmed off as red or deep-pink coral.

* From a monograph issued by the United States Geological Survey.

THE COAL RESOURCES OF JAPAN.

The coal industry in Japan has become important. At present Japan is exporting annually more than 7,000,000 tons, instead of 4,000,000 ten years ago. In this respect, the other countries of the extreme Orient are tributary to the empire of the Rising Sun. It must be acknowledged, however, that the Japanese coal is not of superior quality. It is quite bituminous, producing much smoke and ashes and clogging grates; it is also easily converted into coke, but it has the advantage of being found in a vast region where English and American coal cannot penetrate without long and costly transportation. The great basin of its production is in the island Kiou-Siou. But it is affirmed, after geological investigation, that Yezo contains 600,000,000 tons of the precious combustible, nearly as much as the rest of the country. Of these 600,000,000 tons, some

275,000,000 tons are below the sea level. There are enthusiasts who consider that the quantity estimated does not represent a tenth part of what is actually in existence. We may remain somewhat skeptical as to these optimistic opinions, but it is at least certain that new deposits have recently been discovered at Shinano, at Nagato, and at Akita. This shows the activity of the exploitation.

The mines of Kiou-Siou are much the most important in Japan, especially in the northeastern part of the island, opposite Corea. The coal proceeding from them contains a notable quantity of sulphur, and furnishes 38½ to 40 per cent of combustible gas, though of mediocre quality. But sales are made with great facility at remunerative prices throughout the extreme Orient. The recent mining is not deep, and does not involve great expense. Exportations in great part are from Moji on the Strait of Shimonoseki, which has become a coal port. The combustible is worth, at the ports of Kiou-Siou, 6 to 7 yen per ton. Delivered at Shanghai, qualities for house use are sold at 8 to 11 yen.—La Nature.

GOLD MOLECULES IN THE SOLID STATE.*

By G. T. BEILBY.

MY examination of gold films and surfaces has revealed the fact that during polishing the disturbed surface film behaves exactly like a liquid under the influence of surface tension. At temperatures far below the melting point molecular movement takes place under mechanical disturbance, and the molecules tend to heap up in minute mounds or flattened droplets. These minute mounds are often so shallow that they can only be detected when the surface is illuminated by an intense, obliquely incident beam of light. I have estimated that these minute mounds or spicules can be seen in this way in films which are not more than five to ten micro-millimeters in thickness. A film of this attenuation may contain so few as ten to twenty molecules in its thickness.

When moderately thin films of gold are supported on glass and heated at a temperature of 400 to 500 deg., they become translucent, and the forms assumed under the influence of surface tension can be readily seen by transmitted light. It was in this way that the beautiful but puzzling spicular appearance by obliquely reflected light was first explained as due to the granulation of the surface under the influence of surface tension. Photo-micrographs of these films are exhibited.

Turning now to the mechanical properties of metals, we find that gold has proved itself of great value in the investigation of some of these. It has long been recognized as the most malleable and ductile of the metals, while its chemical indifference tends to preserve it in a state of metallic purity throughout any prolonged series of operations.

The artificers in gold must very early have learned that its malleability and ductility are not qualities which indefinitely survive the operations of hammering and wire-drawing. A piece of soft gold beaten into a thin plate does not remain equally soft throughout the process, but spreads with increasing difficulty under the hammer. If carelessly beaten it may even develop cracks around its edges. We may assume that the artificers in gold very soon discovered that by heating, the hardened metal might be restored to its former condition of softness.

In connection with the study of micro-metallurgy of iron and steel during recent years it has been recognized that heat annealing is, as a rule, associated with the growth and development of crystalline grains, and Prof. Ewing and Mr. Rosenhain have shown that overstrain is often if not invariably associated with the deformation of these crystalline grains by slips occurring along one or more cleavage planes. This hypothesis, though well supported up to a point by microscopic observations on a variety of metals, offers no explanation of the natural arrest of malleability or ductility which occurs when the overstrain has reached a point at which the crystalline grains are still, to all appearance, only slightly deformed. At this stage there is no obvious reason why the slipping of the crystalline lamellæ should not continue under the stresses which have initiated it. But far from this being the case, a relatively great increase of stress produces little or no further yielding until the breaking point is reached and rupture takes place.

The study of the surface effects of polishing, already referred to, had shown that the thin surface film retained no trace of crystalline structure; while it also gave the clearest indications that the metal had passed through a liquid condition before settling into the forms prescribed by surface tension. From this it was argued that the conditions which prevail at the outer surface might equally prevail at all inner surfaces where movement had occurred, so that every slip of one crystalline lamella over another would cause a thin film of the metal to pass through the liquid phase to a new and non-crystalline condition. By observations on the effects of beating pure gold foil, it was found that the metal reached its hardest and least plastic condition only when all outward traces of crystalline structure had disappeared. It was also ascertained that this complete destruction of the crystalline lamellæ and units could only be accomplished in the layers near the surface, for the hardened substance produced by the flowing under the hammer appears to incase and protect the crystalline units after they become broken down to a certain size. By carefully etching the surface in stages by means of chlorine water or cold aqua regia, the successive layers below the surface were disclosed. The surface itself was vitreous; beneath this was a layer of minute granules, and lower still the distorted and broken-up remains of crystalline lamellæ and grains were imbedded in a vitreous and granular matrix. The vitreous-looking surface layer represents the final stage in the passage from soft to hard, from crystalline to amorphous. By heating the beaten foil, its softness was restored; and on etching the annealed metal it was found that the crystalline structure also was fully restored. Photo-micrographs showing these appearances are exhibited. These microscopic observations were fully confirmed by finding well-marked thermo-electrical and electro-chemical distinctions between the two forms of metal, the hard and soft or the amorphous and the crystalline. The determination of a definite transition temperature at which the amorphous metal passes into the crystalline metal further confirms the phase view of hardening by overstrain and softening by annealing.

It was subsequently proved that the property of passing from crystalline to amorphous by mechanical flow, and from amorphous to crystalline by heat at a definite transition temperature, is a general one which is possessed by all crystalline solids which do not decompose at or below their transition temperature. The significance of this fact I venture to think entitles it to more than a passing reference. It appears to me to mean that the transition from amorphous to crystalline is entitled to take its place with the other great changes of state, solid to liquid, liquid to gas, for like these it marks a change in the molecular activity which occurs when a certain temperature is reached. It is entitled to take this place because there is every indication that the change is as general in its nature as the other changes of state. Compare it, for instance, with the allotropic changes with which chemists have been familiar. These are for the most part changes which are special to particular elements or compounds, and are usually classed with the chemical properties by which the substances may be distinguished from each other. Very different is the amorphous crystalline change, for although in particular cases it may have been observed and associated with allotropic changes, yet the causes of its occurrence are more deeply founded in the relations between the molecules and the heat energy by which their manifold properties are successively unfolded as temperature is raised from the absolute zero. At this transition point we find ourselves face to face with the first stirrings of a specific directive force by which the blind cohesion of the molecules is ordered and directed to the building up of the most perfect geometric forms. It is hardly possible any longer to regard the stability of a crystal as static and inert, and independent of temperature; rather must its structure and symmetry be taken as the outward manifestation of a dynamic equilibrium between the primitive cohesion and the kinetic energy imparted by heat. Even before the discovery of a definite temperature of transition from the amorphous to the crystalline phase we had in our hands the proofs that in certain cases the crystalline state can be a state of dynamic, rather than of static equilibrium. The transition of sulphur from the rhombic to the prismatic form supplies an example of crystalline stability which persists only between certain narrow limits of temperature. Within these limits the crystal is a "living crystal" if one may borrow an analogy from the organic world. It can still grow, and it will under proper conditions repair any damage it may receive.

The passage of the same substance through several crystalline phases, each only stable over a limited range of temperature, strongly supports the general conclusion drawn from the existence of a stability temperature between the amorphous and crystalline phases, namely, that the crystalline arrangement of the molecules requires for its active existence the particular kind or rate of vibration corresponding with a certain range of temperature. Below this point the crystal may become to all appearance a mere pseudomorph with no powers of active growth or repair. But these powers are not extinct—they are only in abeyance ready to be called forth under the energizing influence of heat. This temporary abeyance of the more active properties of matter is strikingly illustrated by the early observations of Sir James Dewar at the boiling point of liquid air, and more recently at that of liquid hydrogen. At the latter temperature even chemical affinity becomes latent. In metals it was found that the changes in their physical properties brought about by these low temperatures are not permanent, but only persist so long as the low temperature is maintained. During the past year Mr. R. A. Hadfield has supplemented these earlier results by making a very complete series of observations on the effect of cooling on the mechanical properties of iron and its alloys. The tenacity and hardness of the pure metal and its alloys at the ordinary temperature and at —182 deg. have been compared, and it has been found that these qualities are invariably enhanced at the lower temperature, but that they return exactly to their former value at the ordinary temperature. By the mere abstraction of heat between the temperatures of 18 deg. and —182 deg. the tensile strength of pure metals is raised 50 to 100 per cent. In pure iron the increase is from 23 tons per square inch at 18 deg. C. to 52 tons at —182 deg.; in gold from 15.1 tons to 22.4 tons; and in copper from 19.5 tons to 26.4. This increase is not, I think, due to the closer approximation of the molecules, for the coefficient of expansion of most metals below 0 deg. is extremely small. Neither is it due to permanent changes of molecular arrangement or aggregation, for Mr. Hadfield has obtained a perfectly smooth and regular cooling curve for iron between 18 deg. and —182 deg., and there appears to be no indication of the existence of any critical point between these temperatures. Further, the complete restoration of the original tenacity on the return to the higher temperature shows that no permanent or irreversible change has occurred during cooling. Everything therefore indicates that the increase of tenacity which occurs, degree by degree as heat is removed is due to the reduction of the repulsive force of molecular vibration, so that the primary cohesive force can assert itself more and more completely as the absolute zero is approached.

The metals experimented with by Mr. Hadfield were all in the annealed or crystalline condition, so that the molecules must have exerted their mutual attractions along the directed axes proper to this state. It is to be expected that similar experiments with the metals in the amorphous state may throw light on the question whether and to what extent the crystalline state depends on a dynamic equilibrium between the forces of cohesion and repulsion, or whether a directed cohesion exists fully developed in the molecules at the absolute zero.

The phenomena of the solid state throw an interesting light on the interplay of the two great forces, the primitive or blind cohesion which holds undisputed sway at the absolute zero, and the repulsion due to the molecular vibrations which is developed by heat. This interplay we know continues through the states which succeed each other as the temperature is raised, until a point is reached at which the molecular repulsions so far outweigh the cohesive force that the substance behaves like a perfect gas. The problems of molecular constitution are more likely to be elucidated by a study of the successive states between the absolute zero and the vaporizing temperature than at the upper ranges where the gaseous state alone prevails. The simplicity of the laws which govern the physical behavior of a perfect gas is very attractive, but we must not forget that this simplicity is only possible because repulsion has so nearly overcome cohesion that the latter may be practically ignored. The attractiveness of this simplicity should not blind us to the fact that it is in the middle region, where the opposing forces are more nearly equal, that the most interesting and illuminating phenomena are likely to abound. The application of the gas laws to the phenomena of solution and osmosis appears to be one of those cases in which an attractive appearance of simplicity in the apparent relations may prove very misleading.

* Abstracted from an address delivered before the South African meeting of the British Association for the Advancement of Science.

ANALOGIES BETWEEN LIGHT AND ELECTRIC WAVES.—BRAUN'S EXPERIMENTS.

THOUGH the unity of forces of nature has always been assumed as a logical postulate, the actual development of science followed an almost opposite direction until last century, when the quantitative equivalence and mutual convertibility of the various forms of energy were established. Melloni's researches proved the essential identity of the invisible "calorific," or ultra-red, rays with the luminous rays of the spectrum, and in this identity the invisible "chemical," or ultra-violet, rays were subsequently included. Ampère reduced the phenomena of magnetism to the effects of molecular electric currents, and to Maxwell both visible and invisible rays became electrical and magnetic vibrations. The electro-magnetic theory of light was at first a bold hypothesis, based almost entirely on mathematical analogies and receiving little support from the then known relations between the two classes of phenomena, but it was destined to find a brilliant confirmation in the researches of Hertz, who first produced electrical vibrations under conditions favorable to exact experiment. After this, Hertz, Righi, Lebedew, and others imitated optical phenomena with the aid of electrical rays and thus demonstrated the similarity of the two classes of vibrations.

The analogy, however, was far from perfect and the differences were qualitative as well as quantitative—a fact which is not surprising when we consider the immense disparity in wave length and frequency. The shortest electrical waves yet produced are measured by millimeters (those of Hertz by meters) while the wave length of light is barely a thousandth of a millimeter. This great difference in size suggests a difference in behavior with respect to ponderable matter. For example, both electrical and luminous waves are retarded in traversing ponderable matter and, as a necessary consequence, are refracted, or deviated from their course, if the surface of such matter is oblique to the wave front. It appears probable, *a priori*, that as light waves are comparable in size with molecules the shorter waves would be more retarded, and therefore more strongly refracted, than the longer. This is the phenomenon of dispersion, the cause of the long spectrum into which a pencil of white light is converted by its passage through a prism. On the other hand, as the length of even the shortest known electrical wave, though measuring only a few millimeters, is very great in comparison with molecular dimensions, we would not expect ponderable matter to exert a much greater effect upon such a wave than upon one whose length is measured by meters. This, also, agrees with the facts. The dispersion of electrical waves, though it can be detected, is very much smaller than that of light waves.

Since the discovery of electrical waves physicists have been striving to narrow or to bridge the gap between them and the waves of radiant heat, by shortening the former, lengthening the latter, and showing that exceedingly long heat waves possess properties similar to those of Hertz's "rays of electric force."

Lebedew, who has produced electric waves a few millimeters in length, has nearly reached the limit of technical possibility in this direction, at least with an "exciter" of the Hertzian type. From the other side of the chasm Rubens and his associates, who have identified and studied heat waves as long as 1-40 of a millimeter, have also reached a limit which is not likely soon to be transcended. The gap that remains is still wide but its importance is lessened by the discovery that these "residual rays" of Rubens (so called because obtained pure by successive elimination of shorter wave lengths from a mixture of heat rays) differ considerably from the rays of the visible spectrum and the neighboring ultra-red rays and approximate to rays of purely electrical origin.

Among the phenomena which, at first, appeared to be peculiar to electric waves and to have no analogues in the shorter waves of light and radiant heat, the most striking were those of "Hertz's grating experiment." Hertz found that a grating composed of parallel wires of suitable thickness separated by corresponding intervals, completely stopped a beam of electrical radiations if the wires were at right angles to the wire of the exciter, but not otherwise. The explanation of this phenomenon is that electrical radiations generated by this method are plane-polarized at birth, the electrical vibrations being necessarily parallel to the wire of the exciter in which they originate. Conversely, when they encounter metal wires parallel to themselves they set up vibrations along those wires (by an action analogous to acoustic resonance) and are thus extinguished by the absorption of their energy by the metal. If the wires are perpendicular to the electrical vibrations this resonance and absorption do not occur but the rays pass through the grating, which in this position may be called transparent to them. In intermediate positions the grating weakens without entirely destroying the beam which, on encountering it, is resolved into two beams polarized at right angles to each other, one of which is absorbed, while the other is transmitted.

There appeared to be no optical analogy for this resolution and absorption of rays by a metallic grating. The optical diffraction grating is used for a different purpose and it is essentially unlike Hertz's grating, not only because it is much coarser (relatively to the wave lengths of light) but also because it is a solid engraved plate of glass and metal, so that the lines do not differ from the spaces in material, but only in superficial texture.

More than ten years ago Dubois and Rubens experimented with gratings of silver wires 1-40 of a millimeter thick and the same distance apart and obtained, with ultra-red or "thermal" rays of the greatest wave-length then known (0.006 millimeter) results similar to those of Hertz, but the grating was far too coarse in proportion to the wave length.

Prof. Braun*, of Strasburg, has improved upon this method by making use of a curious phenomenon to obtain gratings of the requisite fineness. When a large charge of electricity is discharged through a fine wire, the latter is volatilized and the metal is projected at right angles to the axis of the wire. If the wire lies on a plate of glass the volatilized metal, on cooling, is precipitated on the glass, not as a uniform deposit but in the form of separate parallel lines perpendicular to the original direction of the wire, thus forming an extremely fine metallic grating. This structure is often discernible under a microscope or even with the naked eye and its existence may be inferred from its effect on polarized light even where the deposit appears uniform under the highest magnification. The proportion of light transmitted is much greater when the vibrations are perpendicular to the lines of the grating than when they are parallel thereto.

This result is a fresh confirmation of the electromagnetic theory of light.

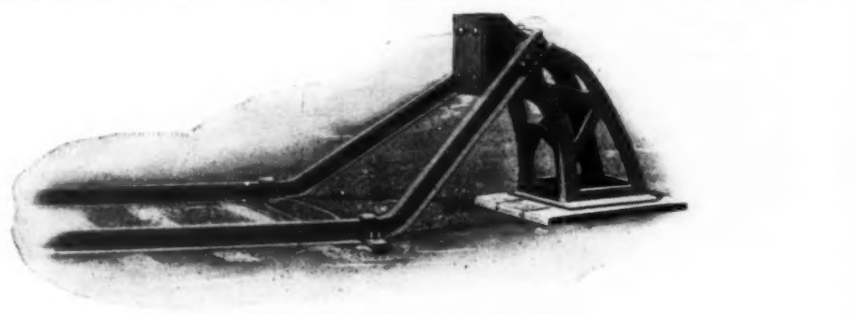
Braun has also studied the action of fine gratings of natural origin, such as occur in animal and vegetable tissues. Ambroun had observed that thin sections of the wood of conifers, after being saturated with a solution of gold chloride and exposed to sunlight, the effect of which is to precipitate the gold in the metallic form, exhibit the phenomena of dichroism, that is to say, they appear of different colors by transmitted light according to the direction of the beam. Braun has proved that this result is due to the formation of a fine grating of gold, running parallel to the grain of the wood and therefore possessing unequal transparencies for light polarized parallel and perpendicular to the fibers. It is impossible to give here the details of these experiments or to reproduce the interesting color drawings with which Braun has illustrated them, but an important practical application must be mentioned. As the effect upon polarized light of thin sections impregnated with a fine deposit of metal may betray the existence of a grating-like, or striated, structure not otherwise discoverable, it becomes possible to carry the examination of organic tissues beyond the limit of the most powerful microscope and thus to advance a step in the study of the structure of organized matter.—Abstracted from an article by Prof. B. Dessau in Umschau.

The wood of the grape is said to be of the most lasting nature, very beautiful in its texture. The columns of Juno's temple at Metapont and also the statue of Jupiter at the city of Appolonium were made from the wood of the vine. The great doors of the cathedral at Ravenna are made of vine planks, some of which are 12 feet long and 15 inches broad.

* Braun's researches are published in the Transactions of the Berlin Academy, 1904, and in the Annalen der Physik, vol. xvi., p. 1 and p. 278, 1905.

A NEW RAILWAY BUMPING POST.

The accompanying illustration shows a new railway bumping post, patents for which were issued to George L. Chatfield, of Chicago, November 14, 1905. This post consists of a metal standard, made preferably of malleable castings. It is hollow, thus giving the greatest strength for the weight. The standard, which is mounted on a suitable base, is held in position by the rails, which are anchored in the ground at the bend, and receive the weight of the cars when they hit the strike plate, with which the post is provided. As a deadwood is placed between the strike plate and the face of the standard sufficient elasticity is provided to avoid any injurious effects to the metal, of which the post is composed; while any variations or setting back of anchorage, as well as slack in rail joints are overcome by having the standard free to adjust itself on the foundation. These posts being constructed of metal also give greater simplicity of construction, possess more lasting quality, and have greater strength than it has been possible to obtain heretofore, and tests that have been carried on with cast-steel standards and eighty-pound rails show great resistance.



A NEW RAILWAY BUMPING POST.

A NEW GAS BURNER.

One of the principal difficulties that has been for a long time encountered in laboratories has been the heating of chemical apparatus, an operation which was performed at first by means of coal which had neither the constancy nor the continuity necessary for delicate operations. It was nevertheless by the use of this defective process that was realized the admirable work that marked the end of the 18th and the beginning of the 19th century. Toward the middle of the latter epoch, however, the use of gas gradually increased and permitted of improving the operatory methods until then in use in chemistry. Bunsen, in creating the burner that bears his name, at once effected an immense progress in this direction. Let us briefly recall the fact that this burner consists in principle of a metallic tube to which the gas is led and which is provided at the lower part with an aperture which is regulatable by means of a collar, and through which is capable of entering a greater or less quantity of air, which, mixed with the gas in the tube, assures the perfect combustion thereof. A large number of modifications have been introduced into the Bunsen burner, but all based upon the same principle.

M. George Meker has very recently constructed a new burner that presents a few peculiarities that permit of obtaining results superior to those realized with the burners employed up to the present.

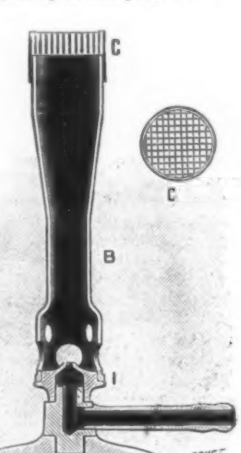


Fig. 1.—SECTION OF THE BURNER.

This burner consists of a gas inlet upon which is placed an injector *I* (Fig. 1), upon which is screwed a chimney, *B*, provided with holes at its base and closed at its upper part by a piece, *C*, characteristic of the system. This piece is a partition comparable to a honeycomb in which the cells are of square section. This arrangement is based upon the fact that a flame will have so much the more difficulty in propagating itself in a direction opposite to that of the current by which it is produced in proportion as it meets in its travel a greater cooling surface.

The form and dimensions of the various pieces constituting the burner have been determined experimentally in such a way as to give the best results from the viewpoint of heating. The system as a whole permits of the mixture of gas and air being made in proper proportions and in a complete manner. Such mixture, burning beneath the partition, gives rise to a homogeneous flame in which the ordinary large blue and cold cone is replaced by a large number of very small blue flames (Fig. 2) about 2 millimeters in height and occupying the entire surface of the partition. Immediately above these flames the temperature is regular and very high.

The constitution of the flame is such that in order to obtain the maximum effect the objects to be heated therein must be placed immediately above the blue zone, say at 6 or 8 millimeters above the partition itself. As the flame is homogeneous, it is silent.

The following models are now being constructed:

No. of burner.	Consumption of gas per hour.	Applications.
1.	45 to 55 liters.	Heating stoves and small apparatus.
2.	125 to 135 liters	For replacing the Bunsen burner.
3.	328 to 350 liters.	For replacing the blowpipe.
4.	600 to 625 liters.	Heating large crucibles.

The judicious use of compressed air, injected into such burners by a special arrangement, has permitted also of obtaining a gain in temperature. Thus, with burner No. 2, supplied with air at a pressure of from 3 to 4 kilogrammes, the melting of platinum in a lime furnace may be effected in a few minutes. Different models of special furnaces have been devised for the purpose of extending the applications of this new system of heating.—Translated from La Nature for the Scientific American Supplement.

EARLY ETHNOLOGY.

In the early discussion of types of mankind and of human prototypes, little account was taken of the western hemisphere and the red race; when not altogether neglected, the aborigines of the American continents were commonly dismissed as emigrant offspring of an old-world stock admitted to the new world during prehistoric times over Behring Strait or some other transoceanic way. Especially during the later half of the nineteenth century the native tribes of the western hemisphere were brought under systematic observation, as were various other little-known peoples; and the observers were impressed by the number of aberrant or outstanding types—peoples like the Japanese, the Papuans and others who fail to conform to the conventional varieties or subspecies of *Homo sapiens*. The new world natives were easily defined as an additional

Fig. 2.—BLUE FLAMES OBTAINED IN THE MEKER BURNER AND TO THE RIGHT A HOMOGENEOUS FLAME WITH LARGE WHITE CONE.

variety or race, at first miscalled Indian in perpetuation of Columbus's error, then known generally as American, and afterward designated specifically as the Amerind type or race; yet even this race was found to present a considerable variety of physical types or subspecies, such as the Eskimo of the north, the so-called "giants" of Patagonia, the light-skinned and almost flaxen-haired denizens of certain mountain districts, and other peoples departing from the copper-tinted, black-maned and medium-size standards. In seeking to classify the local tribes, ethnologists were

led to note industrial and social (i. e., activital) features in addition to physical characters; and so began a system of classifying peoples on the basis of conduct, or in terms of what they *do* as human creatures rather than what they merely *are* as animal beings. In Europe there was a tendency to classify both living peoples and the relics of their precursors in terms of industrial development, and the stone age, the bronze age, and the iron age were defined; in America the native tribes were classified first by the statesman-scientist Gallatin, and more fully by the scientist-statesman Powell, in terms of language; while some authorities classified so many as might be of the world's peoples according to their respective modes of social organization. An outcome of these essays was a system in which known peoples are combined in groups defined by distinctively human attributes; defined on the industrial bases, the groups were some time denoted (1) Paleolithic, (2) Neolithic, (3) Bronze, and (4) Iron, and afterward and more broadly (1) Protolithic, (2) Technolithic, (3) Metallurgic, and (4) Mechanical; and defined on the basis of social organization the peoples were grouped as (1) Maternal (or Avuncular), (2) Patriarchal, (3) Civic, and (4) Democratic—the classes or groups in either case representing types of culture. A more important outcome was clearer recognition of the classific distinctness of man, coupled with living realization that, whatsoever his genetic affinities, man as an active and creative being rises far superior to any quadrumane or other animal prototype—for even the lowest human is an upright, two-handed and two-footed hairless body with his face to his fellows, while even the highest quadrumane (or quadruped) is but a groveling and bristly beast with his gaze and half-hands on the ground.

BENJAMIN FRANKLIN, THE FIRST AMERICAN HEATING AND VENTILATING ENGINEER.*

THE American Society of Heating and Ventilating Engineers happened, by some strange coincidence, to hold its last annual meeting on January 17, 1906. Two hundred years ago upon this same day of the month, Benjamin Franklin was born and upon this bi-centennial anniversary of his birth it seems but fitting that some recognition should be given to this great man by this Society, as he was undoubtedly the originator of what has been commonly recognized as American practice in heating and ventilation.

During the 84 years of his busy life he devoted himself to many pursuits, including literature, politics, and science, and he was widely acknowledged both at home and abroad as being a master in all of these directions. The part of his scientific investigations which appeals most to us is his invention between the years 1740 and 1745 of what he called the Pennsylvanian fireplace, which excellent design was afterward imitated and changed until in many cases its original design and principle were entirely lost sight of and we find many of these so-called improvements bearing the name, even to-day, of the Franklin stove.

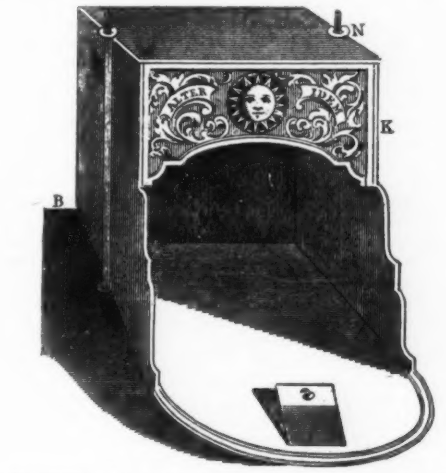
The fact that fuel was growing scarcer and dearer every year caused Franklin to revolt against the fearfully wasteful manner in which such fuel, principally wood, was being used, and his investigation caused him to make a careful study of all the different methods of house heating. After studying their various faults, he was finally led to invent the Pennsylvanian fireplace which resulted in great economy of fuel and in a properly heated room, something hardly known at that time in the sense that we consider a room to be properly heated to-day.

The real Franklin stove was not the mere iron fireplace which has masqueraded under that name, but it was an apparatus which took cold fresh air from outside the house and after warming it in passages kept hot by the escaping gases of the fire, finally discharged it into the room. Had this old original Franklin been enlarged and slightly altered and placed in the cellars of our houses, it certainly would have become the prototype of all of our hot air furnaces.

Franklin died April 17, 1790, and left a large amount of literary work behind him which had hitherto been unpublished. Much of this pertained to the history of his life, and this matter was bequeathed to his grandson, no doubt the intention of the testator being that he would further its publication.

Shortly after the death of Franklin this grandson hastened to London, thinking that the best market for literary projects, and began negotiations with several publishers, but on account of what was considered in those days the very large price he asked for this matter, there was considerable delay in having it accepted. During that time the grandson suddenly withdrew these manuscripts from the market and they disappeared and have never been properly traced. After this initiative effort, all available writings of Dr. Franklin and writings concerning his life were gathered together, and finally, sixteen years after his death, or in 1806, just 100 years ago, these collected works on philosophy, politics, and morals, were published in London. As most of the matter in these books comes directly from Benjamin Franklin's pen, such as his description of the real Franklin stove and his method for ventilating rooms heated by these stoves, as well as his studies concerning the action of smoke and chimneys and his invention of a new stove for burning bituminous coal, I would suggest as a fitting memorial by the American Society of Heating and Ventilating Engineers, that the papers concerning these matters be reproduced in our Transactions, that the matter may be available for all of our members as well as others who have occasion to consult our Transactions. As I am the fortunate possessor of this old edition of Franklin's works, I would be pleased to lend it to the secretary of the Society until the matter could be put in print with its accompanying plates of sketches and drawings.

As I believe that extracts from Dr. Franklin's description of his Pennsylvanian stove, its field of usefulness, and the condition of the art of house heating in America at that time may prove interesting, I will, with your permission, read from this old publication.



FRANKLIN'S PENNSYLVANIAN FIREPLACE.

This description was first published in Philadelphia in 1745.

The growing scarcity of wood for fuel, as mentioned in the first part of this description, is as follows:

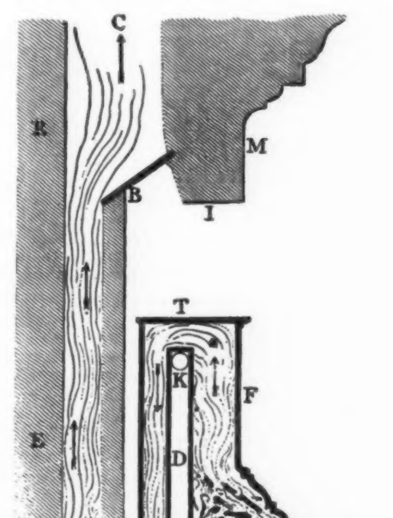
"In these northern colonies the inhabitants keep fires to sit by generally seven months in the year, that is, from the beginning of October to the end of April; and, in some winters, near eight months, by taking in part of September and May.

"Wood, our common fuel, which within these hundred years might be had at every man's door, must now be fetched near one hundred miles to some towns, and makes a very considerable article in the expense of families.

"As therefore so much of the comfort and conveniency of our lives, for so great a part of the year, depends on the article of fire, since fuel is become so expensive, and (as the country is more cleared and settled) will of course grow scarcer and dearer, any new proposal for saving the wood, and for lessening the charge, and augmenting the benefit of fire, by some particular method of making and managing it, may at least be thought worth consideration."

Some of the arguments offered in Dr. Franklin's description are extremely interesting on account of his treatment of the theory of heat. At that time the materialistic theory of heat was generally recognized, which considered fire as a substantial material having weight and substance instead of being considered as merely a mode of motion in accordance with our present theories. Dr. Franklin states:

"1. Fire (i. e., common fire) throws out light, heat,



CROSS-SECTION OF THE PENNSYLVANIAN FIREPLACE.

and smoke (or fume). The two first move in right lines, and with great swiftness, the latter is but just separated from the fuel, and then moves only as it is carried by the stream of rarefied air: and without a continual accession and recession of air, to carry off the smoky fumes, they would remain crowded about the fire and stifle it.

2. Heat may be separated from the smoke as well as from the light by means of a plate of iron, which will suffer heat to pass through it without the others.

3. Fire sends out its rays of heat as well as rays of light, equally every way; but the greatest sensible heat is over the fire, where there is, besides the rays of heat shot upward, a continual rising stream of hot air, heated by the rays shot round on every side.

These things being understood we proceed to consider the fireplaces heretofore in use, viz.:

1. The large open fireplaces used in the days of our fathers, and still generally in the country, and in kitchens.

2. The newer-fashioned fireplaces, with low breasts, and narrow hearths.

3. Fireplaces with hollow backs, hearths, and jambs of iron (described by Mr. Gauger, in his tract entitled 'La Mechanique de Feu') for warming the air as it comes into the room.

4. The Holland stoves, with iron doors opening into the room.

5. The German stoves, which have no opening in the room where they are used, but the fire is put in from some other room, or from without.

6. Iron pots, with open charcoal fires, placed in the middle of the room."

After giving a more detailed consideration to the fireplaces he has classified under the first and second headings, which consisted of the old-fashioned fireplaces with which we are all more or less familiar; fireplaces in which we could stand, with their big fire-dogs or andirons capable of supporting large logs of wood, and found in the older houses along the Atlantic seaboard, Dr. Franklin then comments upon these two styles of fireplace. The first is the large one I have just described, and the second, a modification of this large old-fashioned fireplace, having its opening somewhat contracted in both width and height. In this comment he again considers heat to be a material body, stating:

"In both these sorts of fireplaces, the greatest part of the heat from the fire is lost; for as fire naturally darts heat every way, the back, the two jambs, and the hearth drink up almost all that is given them, very little being reflected from bodies so dark, porous, and unpolished; and the upright heat, which is by far the greatest, flies directly up the chimney. Thus five-sixths at least of the heat (and consequently of the fuel) is wasted, and contributes nothing toward warming the room."

After following this comment with a description of his third classification of fireplaces, he takes up the Holland stove and his comments concerning it show his clear conception of the manner in which stoves of this type heat a room. He states:

"The Holland iron stove, which has a flue proceeding from the top, and a small iron door opening into the room, comes next to be considered. Its conveniences are, that it makes a room all over warm; for the chimney being wholly closed, except the flue of the stove, very little air is required to supply that, and therefore not much rushes in at crevices, or at the door when it is opened. Little fuel serves, the heat being almost all saved; for it rays out almost equally from the four sides, the bottom and the top, into the room, and presently warms the air around it, which, being rarefied, rises to the ceiling, and its place is supplied by the lower air of the room, which flows gradually toward the stove, and is there warmed, and rises in its turn, so that there is a continual circulation till all the air in the room is warmed. The air, too, is gradually changed, by the stove-door's being in the room, through which part of it is continually passing, and that makes these stoves wholesomer, or at least pleasanter than the German stoves, next to be spoken of. But they have these inconveniences. There is no sight of the fire, which is in itself a pleasant thing. One cannot conveniently make any other use of the fire, but that of warming the room. When the room is warm, people, not seeing the fire, are apt to forget supplying it with fuel till it is almost out, then, growing cold, a great deal of wood is put in, which soon makes it too hot. The change of air is not carried on quite quick enough, so that if any smoke or ill smell happens in the room, it is a long time before it is discharged. For these reasons the Holland stove has not obtained much among the English (who love the sight of the fire) unless in some workshops, where people are obliged to sit near windows for the light, and in such places they have been found of good use."

He then proceeds to give a description of his Pennsylvanian fireplace, as follows:

"1. A false back of four inch (or, in shallow small chimneys, two inch) brick work is to be made in the chimney, four inches or more from the true back; from the top of this false back a closing is to be made over to the breast of the chimney, that no air may pass into the chimney, but what goes under the false back, and up behind it.

"2. Some bricks of the hearth are to be taken up, to form a hollow under the bottom plate; across which runs a thin, tight partition, to keep apart the air entering the hollow and the smoke; and is therefore placed between the air-hole and smoke-holes.

"3. A passage is made, communicating with the outward air, to introduce that air into the fore part of the hollow under the bottom plate, whence it may rise through the air-hole into the air-box.

"4. A passage is made from the back part of the hollow, communicating with the flue behind the false back: through this passage the smoke is to pass.

"The fire-place is to be erected upon these hollows, by putting all the plates in their places, and screwing them together.

"Its operation may be conceived by observing the

* An address before the American Society of Heating and Ventilating Engineers.

plate entitled, Profile of the Chimney and Fire-Place.

M The mantel-piece, or breast of the chimney.
C The funnel.
B The false back and closing.
E True back of the chimney.
T Top of the fire-place.
F The front of it.
A The place where the fire is made.
D The air-box.
K The hole in the side-plate, through which the warmed air is discharged out of the air-box into the room.
H The hollow filled with fresh air, entering at the passage *I*, and ascending into the air-box through the air-hole in the bottom plate near
G The partition in the hollow to keep the air and smoke apart.
P The passage under the false back and part of the hearth for the smoke.

"The arrows show the course of the smoke.

"The fire being made at *A*, the flame and smoke will ascend and strike the top *T*, which will thereby receive a considerable heat. The smoke, finding no passage upward, turns over the top of the air-box and descends between it and the back plate to the holes in the bottom plate, heating as it passes, both plates of the air-box, and the said back plate; the front plate, bottom and side plates are also heated at the same time. The smoke proceeds in the passage that leads it under and behind the false back and so rises into the chimney. The air of the room, warmed behind the back plate, and by the sides, front and top plates, becoming specifically lighter than the other air in the room, is obliged to rise; but the closure over the fireplace hindering it from going up the chimney, it is forced out into the room, rises by the mantel-piece to the ceiling, and spreads all over the top of the room, whence being crowded down gradually by the stream of newly-warmed air that follows and rises above it, the whole room becomes in a short time equally warmed.

"At the same time, the air warmed under the bottom plate, and in the air-box, rises and comes out of the holes in the side-plates, very swiftly, if the door of the room be shut, and joins its current with the stream before-mentioned, rising from the side, back and top plates.

"The air that enters the room through the air-box is fresh though warm; and, computing the swiftness of its motion with the areas of the holes, it is found that near ten barrels of fresh air are hourly introduced by the air-box; and by this means the air in the room is continually changed, and kept, at the same time, sweet and warm."

It is interesting to note the provision which is made for the chimney sweeps, as it will be remembered that the wood fuel which was commonly used at this time caused an immense amount of soot and tarry matter to deposit itself along the flues, which caused a diminution in draft or danger from fire when this carbonaceous matter ignited. Therefore, he makes provision for cleaning out back of his fireplace as follows:

"A square opening for a trap-door should be left in the closing of the chimney, for the sweeper to go up; the door may be made of slate or tin, and commonly kept close shut, but so placed as that, turning up against the back of the chimney when open, it closes the vacancy behind the false back, and shoots the soot, that falls in sweeping, out upon the hearth. This trap-door is a very convenient thing."

We next come to a paragraph showing his wonderful conception of the requirements of ventilation as well as heating in connection with the use of his stove. We find in his statements the theories that are commonly accepted to-day, as will be seen in the following quotation:

"In rooms where much smoking of tobacco is used, it is also convenient to have a small hole, about five or six inches square, cut near the ceiling through into the funnel: this hole must have a shutter, by which it may be closed or opened at pleasure. When open, there will be a strong draft of air through it into the chimney, which will presently carry off a cloud of smoke and keep the room clear; if the room be too hot likewise, it will carry off as much of the warm air as you please and then you may stop it entirely, or in part, as you think fit. By this means it is that the tobacco smoke does not descend among the heads of the company near the fire, as it must do before it can get into common chimneys."

It is interesting to note the trouble people had in keeping warm with the old-fashioned methods of heating which were in existence previous to the appearance of this Pennsylvanian fire-place. These points are well brought out in the description of the advantages of his fire-place, in which description he comments upon the short-comings of the other methods of heating.

"Its advantages above the common fire-places are:

"1. That your whole room is equally warmed, so that people need not crowd so close round the fire, but may sit near the window, and have the benefit of the light for reading, writing, needlework, etc. They may sit with comfort in any part of the room, which is a very considerable advantage in a large family, where there must often be two fires kept, because all cannot conveniently come at one.

"2. If you sit near the fire, you have not that cold draft of uncomfortable air nipping your back and heels, as when before common fires, by which many catch cold, being scorched before, and, as it were, froze behind.

"3. If you sit against a crevice, there is not that sharp draft of cold air playing on you, as in rooms where there are fires in the common way; by which many catch cold, whence proceed coughs, catarrhs, toothaches, fevers, pleurisies, and many other diseases.

"4. In case of sickness, they make most excellent nursing rooms; as they constantly supply a sufficiency of fresh air, so warmed at the time as to be no way inconvenient or dangerous. A small one does well in a chamber, and the chimneys being fitted with it, it may be removed from one room to another, as occasion requires, and fixed in half an hour. The equal temper, too, and warmth of the air of the room, is thought to be particularly advantageous in some distempers."

The requirements in a stove or fireplace to enable one to start a fire, to extinguish it or to hold the fire in check so that it may smolder slowly through the night, and be easily started the following morning, are shown in the provisions made by Dr. Franklin in his Pennsylvanian stove.

In examining the sectional view it must be understood that the upper front part of the stove opposite the letter *F* was only partially closed, while the lower part of the stove shown by the irregular line of molding extending from the hearth, *H*, upward to the straight line, *F*, was simply an open space between the two sides of the stove, opening into the room, and into this space the fire-dogs or andirons were placed when the fire was in operation. Under such conditions it is quite difficult to start a fire with a cold chimney, so Dr. Franklin provided an iron shutter which slides up and down the face, *F*, like a window shade, so as to partially or entirely close the opening into the room, and thus facilitate the handling of the fire, as stated by him, as follows:

"A fire may be very speedily made in this fire-place by the help of the shutter, or trap-bellows, as aforesaid.

"A fire may be soon extinguished, by closing it with the shutter before, and turning the register behind, which will stifle it, and the brands will remain ready to rekindle.

"The room being once warm, the warmth may be retained in it all night.

"And lastly, the fire is so secured at night, that not one spark can fly out into the room to do damage. .

"With all these conveniences, you do not lose the pleasing sight nor use of the fire, as in the Dutch stoves, but may boil the tea-kettle, warm the flat-irons, heat heaters, keep warm a dish of victuals by setting it on the top, etc."

We next come to a most interesting statement by Dr. Franklin which shows the prevailing idea concerning the prospects of obtaining coal for fuel in this country. At that time, the black stone, as it was called in England and Germany, had been dug from pits and was burned to comparatively poor advantage, but nevertheless giving off heat as it does, was recognized as a possible fuel of the future, and some of this pit coal (as it was called on account of the quarrying methods used for removal from the earth) was brought over to America, but the idea that any of this wonderful substance could possibly be found in this country was very remote in the minds of those who gave the matter any consideration whatsoever. This is expressed by Dr. Franklin in the following paragraph, referring to countries in the north of Europe:

"The mentioning of those northern nations, puts me in mind of a considerable public advantage that may arise from the general use of these fire-places. It is observable that though those countries have been well inhabited for many ages, wood is still their fuel, and yet at no very great price; which could not have been, if they had not universally used stoves, but consumed it as we do, in great quantities, by open fires. By the help of this saving invention our wood may grow as fast as we consume it, and our posterity may warm themselves at a moderate rate, without being obliged to fetch their fuel over the Atlantic; as, if pit-coal should not be here discovered (which is an uncertainty) they must necessarily do."

THE SAFEGUARDING OF LIFE IN THEATERS.

President John R. Freeman of the American Society of Mechanical Engineers at the opening meeting read a paper on the Safeguarding of Life in Theaters, which is herewith abstracted.

The direct cause of the great loss of life in the theater disasters which have taken place in various cities at various times has been the outburst of flames and poisonous gases from the combustion on a stage crowded with scenery. The opening of a door in the rear of the stage, bringing an inrush of air, combined with the absence of suitable smoke vents over the stage, together cause an outburst of smoke from beneath the proscenium arch, and result in death by burning and suffocation to the spectators in the crowded gallery. There have been at least four great disasters of this kind, all of them of sickening proportions, and all of them caused by practically the same chain of circumstances. In 1876 at Conway's Theater in Brooklyn the scenery was set on fire and, by the opening of large doors in the rear of the stage, a blast of suffocating smoke was produced, killing about 300, all of whom were in the upper gallery. At the fire in Exeter, England, within five minutes 200 were killed, mostly in the upper gallery. In 1881 at the Ring Theater in Vienna with an audience of about 1,800 a large door in the rear of the stage was opened the minute the fire was discovered, letting in a blast of air that sent the flame through the proscenium arch. The iron curtain could not be lowered, special exit doors were found locked, and 450 were killed, mostly in the gallery. The Iroquois disaster in Chicago is too recent and well known to require a detailed description.

The problem of protecting the audience in a theater from the effects of a fire on the stage is not one that requires any new knowledge or any investigation along lines not already understood by engineers. After the Vienna disaster a committee of the Austrian Society of Engineers was appointed to investigate this matter and the results of their investigations have been on record for a great many years. The main problem is to give prompt and certain vent to the smoke and suffocating gases elsewhere than through the proscenium arch. The construction of the stage, arch, and scenery loft in a modern playhouse, as may be seen by looking at a cross section of any such structure, bears a remarkable resemblance to that which would be presented by taking a section through an ordinary open fire-place. The conditions would thus seem to be exceedingly favorable for creating a draft from the audience toward the stage, instead of in the contrary direction, provided an outlet is made at the top of the chimney-like loft for an escape for the hot gases. There seems to be some recognition of this fact in the minds of the men who framed the various regulations applying to theater construction in the various cities. For instance, the building law in the city of New York reads as follows: "There shall be provided over the stage metal sky-lights of a combined area of at least one-eighth of the stage, fitted with sliding sash and glazed with double thick sheet glass, . . . the whole of which skylight will be so constructed as to open instantly on the cutting or burning of a hempen cord. . . . Immediately underneath the glass skylight there shall be wire netting, etc." The ratio of smoke vent area to stage area given in this extract from the building laws is about that usually used in proportioning the area of the chimney and fire-place opening and agrees very well with the Vienna experiments and the practice which has been found desirable in England and other places where this matter has received attention. There are, however, a few almost criminally dangerous points about this New York law. The evident purpose of the thin glass is to cover the opening with something that will break out under heat if the mechanism for sliding off the cover fails. The wire netting is to prevent any pieces of broken glass from falling to the stage. This requirement as to the glass is well meant but it would be too slow in breaking out. Unconsciousness and suffocation come very quickly in an atmosphere of smoke. The wire netting is a positive danger as often applied. The Austrian experiments demonstrated that the force of the upward draft caused by the fire on the opening of the smoke vents, carries with it large pieces of flying scenery and other debris which lodge against the screen and almost entirely close the opening. This provision is one that should be changed at once. On Pres. Freeman's visit to the remodeled Iroquois he found the opening in their new vent shaft screened in a way that would, possibly in a minute's time, put it into a condition of uselessness.

Another dangerous provision is the use of a hempen cord instead of a fusible link for holding the skylight closed. There is no good reason to expect that a hempen cord in this position, in smoking atmosphere from which the oxygen has been largely removed, will burn off until a majority of those in the gallery have been suffocated. Fusible links have been in common use on automatic fire shutters in factories for nearly twenty years. It is almost beyond belief how slowly and scantily these have found their way into the fire protection of theaters.

Not only are the laws relating to this subject badly framed but they have in many cases been executed with a carelessness that is really criminal. In one of the newest and best theaters of New York the speaker found the ventilator with a broad sheet of heavy canvas laced tightly across its opening with marline. As the stage carpenter remarked, the cracks around the ventilator let in too much cold air. No building inspector had objected and the carpenter could not be made to see any danger. "It would burn off in any bad fire," he stated. So it may, but not until those in the gallery are mostly dead.

Concerning the design of smoke vents, there are practically none in actual use which have been designed intelligently and with a full consideration of the importance of details. The fundamental requirements are: Absolute certainty of opening by force of gravity in spite of neglect, rust, dirt, frost, snow or expansion by heat, twisting or warping of framework. Quickness of opening to be secured by automatic links of improved design and by hand control from the prompter's stand and the station of the stage fire guard. The operative mechanism should be simple and massive, built more like rolling mill machinery than in accordance with watchmaker's practice. The poise weights should give a constant tension of 25 pounds or more on the release cord. The vent should be of such form that it can be tested daily by partially opening it and closing it again, preferably by means of the cord running to the prompter's stand. It should not be so loosely fitting as to let in cold drafts to tempt the stage hands to fill up the opening beneath it. Mr. Freeman presented designs for two types of ventilators one with hinged shutters, the other with sliding shutters, both designed to meet the requirements outlined above.

The second requirement that should be introduced is the use of a well designed and freely acting fireproof curtain. Most theaters outside of Chicago at the present time are furnished with a fire curtain made from heavy canvas woven from asbestos fiber. For some time after

the Iroquois fire there was some doubt as to whether the curtain in that theater was really made of asbestos, as its owners claimed. It fell as mere rubbish to the stage and outwardly little resembled the material of which it was supposed to be made. This curtain was an utter failure in three different ways. It could not be lowered, and stuck fast after passing a distance variously estimated at from one-fourth to one-half the height of the arch. The curtain was improperly hung, being supported at the top in part by being clamped between thin strips of pine wood about four inches wide by three-fourths high. These asbestos curtains in many theaters to-day are hung from a batten of white pine to which they are nailed across the top. When subjected to actual fire the Iroquois asbestos curtain lost its strength and fibrous quality almost completely and became so brittle that it was incapable of standing the pressure of a strong draft of air and was too weak to hang under its own weight.

This last defect is the serious defect of asbestos as a material for a fireproof curtain. Through various channels Mr. Freeman obtained samples from three feet to six feet square from all prominent American manufacturers of theater curtains and asbestos cloth. He also cabled to London and had a competent architect collect samples of asbestos curtain cloth from leading manufacturers and dealers, with instructions to use every effort to procure canvas woven from French or Italian, or other than Canadian fiber. When hard pressed for the pedigree of their samples none of these makers would furnish the canvas under a guarantee that it was made from anything other than the Canadian fiber, and the chemical analysis confirmed the belief that this was the only material used.

There are two or three minerals which go under the name of asbestos. The Canadian fiber is chrysotile. This is the common asbestos of commerce and possesses in a greater degree than the others the properties required for spinning and weaving. Themolite and a third material called anthophyllite, of which no great quantity has been found, are obtained from Georgia, Siberia, and South Africa. They resist heat to a very much greater degree than the Canadian fiber, which loses its strength at about 660 deg. C., but they are for the most part too brittle for spinning.

Three series of tests were made to determine the fitness of asbestos as a material for a fireproof curtain. The first of these was undertaken by Prof. Fuller, of the Massachusetts Institute of Technology, and was made with a degree of attention to details which renders the conclusions arrived at of very great importance. It was found that every one of these specimens of asbestos canvas, English and American alike, when heated from two to five minutes a little below redness in a common gas flame, or barely to redness in the Bunsen flame, lost 60 to 90 per cent of their strength and the fiber became very brittle. The samples which had interwoven brass wires were no stronger than the other samples, and on cooling they regained little of the strength due to the wire.

A second series of tests was made at the Underwriter's laboratory in Chicago on curtains about six feet square. On account of defects in the furnace this test was inconclusive. In the third series of tests Profs. Crosby and Warren, of the Massachusetts Institute of Technology, made an exhaustive search through the extensive cabinets of the Institute and of the Boston Society of Natural History in the hope of finding specimens from some locality that possessed all the qualities commonly attributed to asbestos. The result of this search, in brief, was that nothing was found possessing characteristics materially different from the hydrous Canadian fiber on the one hand, and the anhydrous fiber from Georgia on the other. Those of the first class lost their strength at a heat which drove the water off; the second class were too stiff or brittle to allow their use in a fabric.

In the Chicago tests there were tried different combinations of asbestos, asbestos felt, asbestic cement with thin steel plates and combined with wire netting, the asbestos being placed on the stage side in the hope that it might shield the steel plate curtain from the action of the fire and thus prevent the heating of the steel to redness and the consequent disturbance of the audience. It is plain to all who witnessed these tests that the steel curtain protected with some asbestos material on the fire side possessed far greater strength and endurance against fire than the simple asbestos. The general type of steel proscenium curtain finally adopted in Chicago and required at all theaters, was worked out somewhat hurriedly. The curtain with the framework for supporting it weighs from two to six tons. The handling would be improved by more substantial iron channels to hold the edge, and by the addition of positive down-haul tackle or some arrangement by which the weight could be thrown off, for now the great weight of these curtains is so nearly counterpoised that conceivably the air pressure against this surface of about 1,000 square feet might prevent the slight excess of gravity from lowering it.

The question of fireproofing scenery was also investigated and in this matter also extensive tests were made by men thoroughly competent in the matter, and consultations were held with several experienced scenic artists, and the conclusion arrived at was that the best possible in this line is far from satisfactory. The petty tests that have long satisfied several distinguished chemists are very misleading as guides as to what may happen on a larger practical scale, and the best we can hope to accomplish is to flame-proof a fabric so that it will not ignite from a match or electric spark or a gas jet, or so that, if ignited, it will not burst into flame. After investigating this question Mr. Freeman is of the opinion that we must after all rely on the safeguards of the engineer rather than those of the chemist. Disappointing conclusions resulted also from the investigations into fireproof woods and fireproof paints.

Perhaps the most interesting of all the experimental results recorded in this paper are those which relate to the composition of the chemicals contained in the various dry-powder and liquid fire extinguishers on the market. It is scarcely necessary to do more than call attention to the accompanying tables, which are compiled from the results of analyses made by reputable chemists on all the different varieties of extinguishers that could be found in the open market in and about New York. It will be noticed that the composition sold under the name of "Kilfyre," of which there were several tubes on and about the stage of the Iroquois, is composed almost entirely of bi-carbonate of soda or "salaratus," as the cook calls it. This, in the form and quantity in which it is found in the tubes, could be bought for about 10 cents; the extinguishers are sold at retail for as high as $3.00 apiece. Practically all these dry extinguishers are composed of common bi-carbonate of soda, frequently disguised by the mixture of cheap coloring matter like Venetian red. Possibly

TABLE SHOWING RESULTS OF ANALYSIS OF DRY POWDER FIRE EXTINGUISHERS.

PER CENTS OF CHEMICALS BY WEIGHT.

Price	Name of Extinguisher.	Bi-carb. Soda.	Red Ochre.	Yellow Ochre (or Iron Ore).	Fuller's Earth.	Common Salt.	Amm. Carb.	Sodium Phosphate	Nitrate Soda.	Charcoal	Fire Clay.	Sodium Sulphate.
	"Kilfyre"	97.5	2.5	....	....	....	....	....	....	....	....	....
$3.00	"Kilfyre"	96.0	4.0	....	....	....	....	....	....	....	....	....
3.00	"Kingfyre"	97.4	2.6	....	....	....	....	....	....	....	....	....
3.00	Fyricide	99.5	0.5	....	....	....	....	....	....	....	....	....
	"Fore Dust"	94.8	....	5.2	....	....	....	....	....	....	....	....
3.00	"Improved"	87.6	....	12.4	....	....	....	....	....	....	....	....
3.00	Atomized	95.0	....	5.0	....	....	....	....	....	....	....	....
3.75	Driggs	89.5	....	....	10.5	....	....	....	....	....	....	....
3.00	Pan-American	30.6	....	37.9	....	7.4	2.3	8.1	....	....	....	12.9
3.00	Phenix	81.2	....	4.0	....	....	....	....	....	....	14.8	....
3.00	Phenix	82.1	....	17.9	....	....	....	....	....	....	....	....
3.00	Manville	95.5	....	1.2	....	....	....	....	2.6	0.7	....	....
3.00	Manville	96.0	....	4.0	....	....	....	....	....	....	....	....

Another series of analyses ran as follows:

Price	Name of Extinguisher.	Na_2O Soda.	CO_2 Carb. Acid.	Insoluble Matter (Iron Ore).	Water in Bi-carb. by Diff.	NaCl Common Salt.	NH_3 Ammonia.					Na_2SO_4 Sodium Sulphate.	Starch.
$2.50	Kilfyre	35.4	50.6	4.0	10.0	....	....	......	......	....	....	....	....
	Monarch	....	....	....	....			......	......	....		....	....
3.00	Pan-American	15.3	20.3	41.1	14.1	6.7	0.4	......	......	....	....	2.0	....
1.00	Eclipse	32.6	43.2	3.4	12.0	....	....	......	......	....		....	8.8
2.00	Manville	35.0	48.0	4.0	13.0	....	....	......	......	....	....		....
3.00	Phenix	30.1	41.8	17.8	10.1	....	....	......	......	....		....	....

Another series:

Price	Name of Extinguisher.	Bi-Carb. Soda.	Mono-Carb. Soda.	Iron Oxide.	Insol. Dust.	Loss at Red Heat.	Amm. Carb.	Common Salt.	Sodium Sulphate	Insol. Iron Ore.	Water, etc.	Starch.	Clay.
....	Monarch	93.7	2.4	3.8	....	35.7%	....	....	....	....	....		....
....	Fyricide	94.7	4.6	0.7	....	38.8%	....	....	....	....	....	....	....
....	Pan-American	34.5	4.4	....	....		1.1	6.7	2.0	41.1	10.2	....	....
....	Eclipse	87.9	....	....	....	....	....	....	....	....	....	8.8	3.3
....	Kilfyre	96.5		....	3.5	....	....	....	....	....	....	....	....
....	Swan	97.2	1.7	....	1.0	....	....	....	....	....	....	....	....

ANALYSES OF THE CONTENTS OF HAND GRENADES.

	Per Cent.
Hayward Hand Grenade:	
Common salt	22.3
Other solids	0.4
Total	22.7
Harden Hand Grenade:	
Common salt	18.5
Salammoniac	6.7
Total	25.2
Babcock Hand Grenade:	
Common salt	21.2
Chloride of calcium	6.5
Total	27.7

this material has some small value for a certain class of fires. Doubtless it is wise to carry a few tubes of this on an automobile. Doubtless in confined situations the bi-carbonate powder may sometimes do remarkably well, but it should never be used to give a full sense of security about the stage of a theater. Underwriters do not accept it in factory fire protection. They recommend that it be thrown into the rubbish heap. Pails of water are far more reliable. In general the materials of which all these extinguishers are composed render them of doubtful value on the smallest fire and entirely worthless for a fire with full ventilation. On the other hand, soda-water fire extinguishers consisting of a copper cylinder containing two, three or four gallons of a strong solution of bi-carbonate of soda, with a bottle of acid at the top so arranged that it can be upset into the soda and water, thereby generating a strong pressure by the evolution of carbonic acid gas, are excellent for many places where pails would be unsightly.

The accompanying table containing the analysis for the contents of three makes of hand grenades purchased in the open market is fully as interesting as the one relating to the dry powder. The materials are inert and their only advantage over plain water is that they do not freeze at ordinary winter temperatures.

After everything possible has been done to prevent the starting of a fire in a playhouse and to keep it within the bounds of the stage after it has been started, there still remains the exceedingly important question of furnishing a safe and free means of escape to the audience, above all to those in the upper galleries. A type of fire escape has been developed under the building laws of Philadelphia, primarily for use in factories, which is so remarkably efficient and so far ahead in point of safety of anything that exists elsewhere, that it is a wonder it has not been copied in other cities. It is somewhat expensive, but the safety it gives is well worth the extra cost. The fundamental idea is that the stairway proper shall be absolutely cut off from the various rooms and floors which it serves. One must go out from the room into the open air and then enter the stairway. Once within this he can proceed without danger to the bottom. The total number of stairway exits and the total width of the stairway per hundred persons should be two or three times as great for the gallery as for the other parts of the house, and all exits should run in such a direct and obvious course that a person once in them could not fail to find his way to the bottom, even in total darkness. A sad loss of many lives occurred in the Iroquois by reason of a blind passageway from the gallery which led nowhere in particular, but extended out from the main exits in such a way that those rushing downward naturally took it as the line of escape, and a mass of women and children were caught in this *cul de sac* and doomed to suffocation.

AMERICAN SHIPBUILDING.

ACCORDING to the records of our Bureau of Navigation the product of American shipbuilding for the last five years, outside of warships, has been as follows:

	Vessels.	Gross tonnage.
1901	1,322	376,129
1902	1,262	429,327
1903	1,159	381,970
1904	1,065	265,104
1905	1,054	306,563

There is nothing to boast of in that record. In 1905 we fell short of 1901 by 268 vessels and 69,566 tons. In the six months ended December 31 last we built 542 vessels of the following classes and tonnage:

	Number.	Tonnage.
Wood, sailing	169	22,228
Wood, steam	318	11,191
Steel, sailing	4	2,551
Steel, steam	51	100,127
Totals	542	136,097

In the last half year of 1904 we built the same number of vessels, but the aggregate tonnage was only 92,598, leaving us 43,499 tons ahead for the last half of 1905.

The 542 vessels built in the six months of 1905 were for the following trades:

	Vessels.	Tonnage.
Great Lakes	57	81,094
Atlantic and Gulf	341	47,383
Pacific	58	4,605
Western rivers	84	2,190
Porto Rico	2	15

Not a single vessel was built for the Hawaiian trade. Had it not been that our shipbuilding for the Great

Lakes amounted to 30 vessels, of 78,811 tons, in excess of the last half year of 1904, we should have been 30 vessels and 34,812 tons short of the corresponding period of the previous year.

SIMPLE PHOTOGRAPHIC AND PHOTO-MICROGRAPHIC APPARATUS.

A PHOTOGRAPHIC outfit that will do very good execution may be purchased for a few dollars, but notwithstanding the small expense, many are deterred from making a beginning in photography on account of the first outlay.

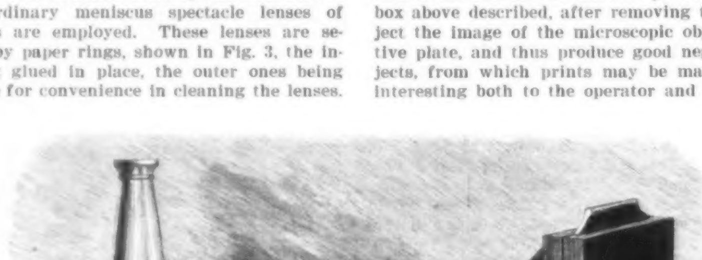
While first class photographic instruments can be made only by makers having the greatest skill and large experience, an ordinary camera that will serve the purpose of the amateur may be made by the amateur himself with the expenditure of an insignificant sum for materials.

Figs. 1 to 12 show a camera tube, box, and tripod the materials of which cost less than a dollar. The construction is within the range of any one having a little mechanical ability. The camera is intended for 4 by 5 plates, therefore the size of the plate holder and the focal length of the tube will determine the size of the camera box. To avoid turning the camera or plate holder, the box is made square, and the inside dimensions of the plate holder are such as to permit of placing the plate either horizontally or vertically, according to the subject to be photographed. The plate holder is $5\frac{3}{4}$ inches square inside, and is provided with a wooden back of sufficient thickness to support the hooks employed for holding the plate. There are four V-shaped wire hooks, *a*, at the bottom of the holder, two for receiving the end edge of the plate, and two farther apart, and arranged higher up, for receiving the side edge of the plate; and near the top of the holder there are three Z-shaped hooks, *a*, one in the center for engaging the end edge of the plate, and one near each side of the holder for receiving the side edge of the plate. The top of the frame is slotted, and the sides and bottom are grooved to receive the slide, which covers the plate before and after exposure. To the under surface of the upper part of the frame of the plate holder is attached a looped strip of elastic black cloth, such as broadcloth or beaver, which closes over the slot of the plate holder, as shown in Fig. 10, when the slide is withdrawn, and thus shuts out the light. The interior of the plate holder, as well as the slide, should be made dead black, by applying a varnish made by adding three or four drops of shellac varnish to one ounce of alcohol, and stirring in lampblack until the required blackness is secured.

The main frame of the camera box is made square, and is secured at right angles to the base board. The frame is provided with a narrow bead or ledge that will enter the front of the plate holder and exclude the light.

To the front of the frame are secured four trapezoidal pieces of pasteboard, of the form and size given in Fig. 6. These pieces of pasteboard are secured to each other and to the camera box frame by tape, glued on as shown. If the box is made of junk board, it may be nailed together with wire nails. In this manner a pyramidal box is formed which is strong, light, and compact. In the smaller end of the box is fitted the beveled centrally apertured block shown in Fig. 7. The aperture of this block must be made to fit the camera tube shown in Figs. 1 and 2, after having received a lining of plush or heavy felt.

The camera tube may consist of paper or metal. Paper answers well, and costs nothing. The internal diameter of the tube is determined by the diameter of the lenses. Ordinary meniscus spectacle lenses of eight-inch focus are employed. These lenses are secured in place by paper rings, shown in Fig. 3, the inner rings being glued in place, the outer ones being made removable for convenience in cleaning the lenses.



MICROSCOPE AND CAMERA ARRANGED FOR PHOTO-MICROGRAPHY.

The lenses are arranged with their convex sides outward; the distance between them is $1\frac{1}{4}$ inches, and in one side of the tube, half way between the lenses, is made a slot to receive the diaphragms, as shown in Figs. 1 and 2. Upon each side of the slot, within the tube, are secured flat rings, shown in Fig. 4, which together form a guide for the diaphragms, as shown in Fig. 2.

The tube is adjusted at the proper focal distance from the plate by temporarily securing at the back of the box a piece of ground glass or tracing paper, in exactly the same plane as that occupied by the plate in the plate holder. The tube is then moved back and forth until a focus is obtained which shows the image fairly sharp throughout the field. In arranging for a fixed focus, it is perhaps best to favor the foreground rather than the distance. The tube should move with sufficient friction to prevent it from being easily displaced. By using a small diaphragm, it will be found unnecessary to focus each subject separately.

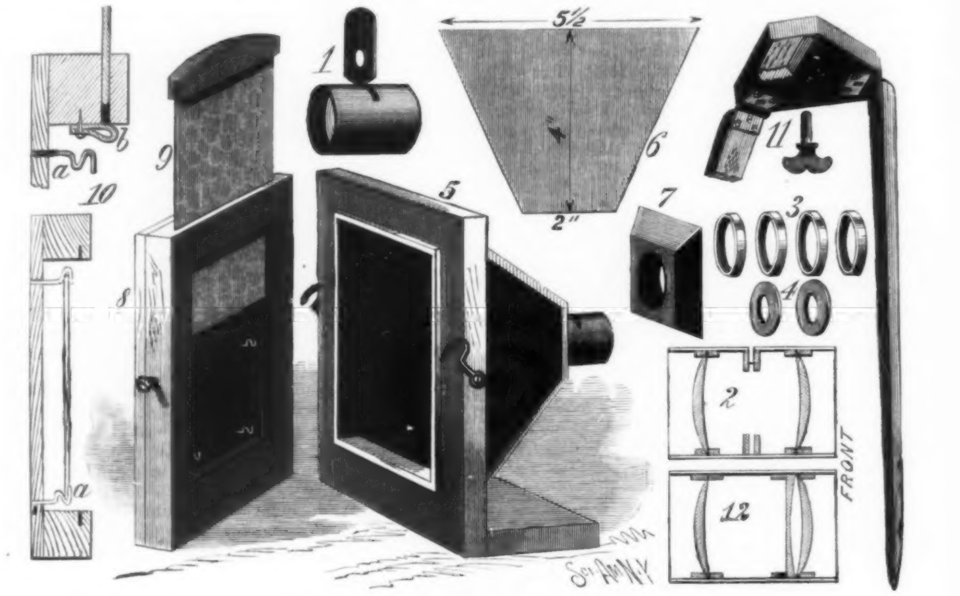
In Fig. 12 is shown a combination of cheap lenses devised by Mr. Henry Mead, which is effective for portraits and for other classes of work when focusing is admissible. It consists of two meniscus lenses, each of $8\frac{1}{2}$ inch focus, having their convex sides arranged outwardly, and a plano-concave lens, 16-inch focus, arranged with its concave side against the concave side of the outer lens of the system. The plano-concave and the rear meniscus lenses are arranged $1\frac{1}{2}$ inches apart. Diaphragms may be used as in the other case, and a box about 8 inches deep will be required.

The tripod is formed of a triangular centrally apertured board, to which are hinged three tapering wooden legs, by means of ordinary butt hinges, as shown in Fig. 11. The base of the camera box is secured to the tripod by means of an ordinary thumb screw.

This outfit will enable the amateur to cultivate his tastes, and learn much about photography. Dry plates will, of course, be used. They are procurable almost anywhere, and are inexpensive. As to the treatment of plates after exposure* and printing and toning, the reader is referred to the works on the subject of photography. The amateur who possesses one of the microscopes described in a previous article of this series may arrange it for projection as described on page 393 of Vol. lvi. of the SCIENTIFIC AMERICAN, and may insert the end of the microscope tube in the camera box above described, after removing the tube, and project the image of the microscopic object on the sensitive plate, and thus produce good negatives of the objects, from which prints may be made which will be interesting both to the operator and his friends. The eyepiece of the microscope referred to is a very good objective for photo-micrography. In photographing microscopic objects, it will be necessary to employ a focusing ground glass, and to focus very carefully by the aid of a magnifier.

Slow plates are preferable for this use, as they bring out the detail much better than fast plates. The time of exposure will vary with the object, from fifteen seconds to a minute or more.

Fig. 13 shows the arrangement of the lantern, the microscope, and the camera box. It will be noticed that the annular space in the end of the camera box around the microscope tube is stopped by a black cloth wound loosely around the microscope tube. This and other precautions are necessary for preventing the light from reaching the plate except through the object and the microscope.



SIMPLE PHOTOGRAPHIC CAMERA.

* See SUPPLEMENT No. 541,

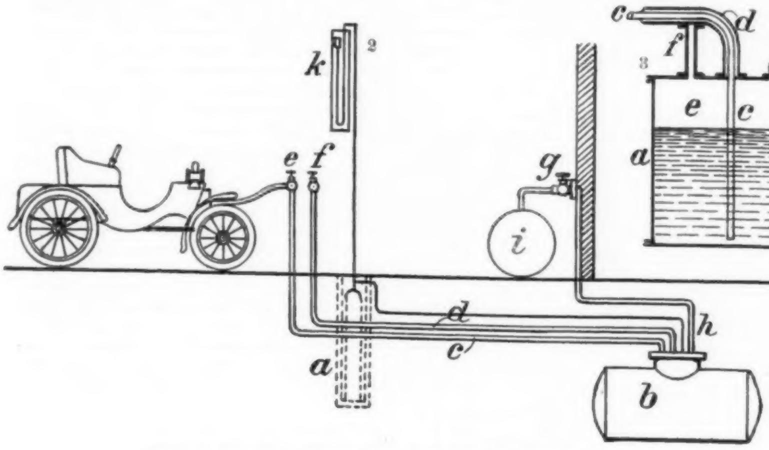
DEGREASING WOOL.

SHEEP'S wool, in a crude state, contains from 20 to 80 per cent of grease, or "yolk," so called, a mixture of dirt, saponaceous substances, and real wool-grease, the quantity depending on the fineness of the wool and on the previous washing of the sheep. This mixture, on treatment of the wool with water, dissolves into a muddy, foamy liquid, which was formerly, for the most part, allowed to run to waste. Now-a-days, at least in the wool-combing and spinning establishments which are equipped with modern machinery, the washing water is kept and its valuable constituents, grease and fatty acids, extracted.

If an acid is added to a saponaceous solution, the soap is decomposed, and the free fatty acid comes to the surface, in a melted or solid form, while the fats, which were held only in emulsion by the solution, are separated. This is the basis of a method by which "yolk" and fat are extracted from the waste water of wool-washing. The water is left to stand for a while, in spacious receivers, or carried through a succession of clarifying vats, where the coarser solid impurities are deposited. It is then drawn off into large vats and mixed with a slight excess of sulphuric acid. Chamber acid is generally used, and the quantity determined by previous experiment. The liquids are thoroughly mixed by stirring with long sticks, and warmed to about 50 deg. C., by forcing in steam, to hasten the decomposition. The soap lye is "broken" by the acid, and the fatty acids settle upon the surface, bringing with them the wool grease in a dirty, granular mass. After standing for some hours, the liquid underneath, which contains sulphates of the alkalies, some sulphuric acid, and sometimes glycerine, is let off, and the mass of fat made to drop upon filters of cocoanut matting and pack-cloth. The watery liquid which runs through cannot be allowed to enter public streams, on account of the tendency of its free acids to putrefy, and must first be made harmless by precipitation with green vitriol and milk of lime, a process which requires space and labor. The mass of fat, which still contains a good deal of dirt, of organic and inorganic nature, remnants of fiber, etc., is thrown into pressing cloths, put into a steam-heated press, and there subjected to slow heating under gradually increasing pressure. The fat melts and runs, together with a watery liquid, into a receiver, out of which it is carried, still in a liquid state, into a vessel lined with lead, and there purified by boiling with a little dilute sulphuric acid. The acidulous liquid is let off, and the oil drawn into casks, where it stiffens to a soft, yellowish brown mass, of unpleasant odor, called crude wool grease (in England "Yorkshire grease"). The residue of the pressing, which still contains 10 or 15 per cent of fat, and also the pressing cloths, is treated with sulphide of carbon to extract this, and the product, after the sulphide of carbon has been itself extracted again, is worked into a kind of illuminating gas, by distillation in red hot iron retorts.

According to another method, the washing water is treated with milk of lime, or with calcium chloride, and the soap is separated as lime-soap, together with the wool grease, while the rest of the liquids, differently from the acidulous solutions of the preceding method, can safely be allowed to run off into the public streams. The precipitate is decomposed with hydrochloric acid, and treated as in the foregoing method, or else worked up directly into illuminating gas.

The composition of the fatty substances extracted varies greatly, according to the character of the wool and the soap used in washing. Very greasy wool, washed with soap without any previous washing, yields a fat which contains a considerable amount of unsaponifiable substances. The fats obtained from less greasy wool consist chiefly of the fatty acids of the soap used in washing, and less real unsaponifiable wool grease. Wool which has been washed on the sheep, or after shearing, gives soap lyes, in the factory washing, which yield little, but good fat. If large quantities of alkaline carbonates are used in washing instead of soap, the waste water may contain so little fat that the cost of extraction will exceed the value of the product. If the fat is distilled, as is done for many purposes, hydrocarbons are formed by partial decomposition.



FIGS. 2 AND 3.—DIAGRAM OF AUTOMOBILE PLANT.

Wool for combing is oiled after washing, usually with Gallipoli olive oil, to facilitate the combing, and then washed again.

In many spinning mills the water from the first washing is put with that of the second, but it is better to handle the latter separately, as it contains but little unsaponifiable fat, and is more valuable than the other. The waste water from yarn washing and piece washing, and fulling, also yields better fats, consisting of the fatty acids of the soap and vegetable oils. These can be easily and advantageously made into soap. The extracted fat is used largely as lubricating grease, and for rubbing sheep in winter. Large quantities, together with other extracted oils, are distilled with superheated steam, and then separated by means of pressure under heat, into a liquid substance (olein) and a solid one (stearin). The liquid portion, which consists largely of oleic acid, is extensively used in dressing leather, and also as spinning oil for inferior grades of wool. Many attempts have been made to utilize it in the manufacture of soap, but they have failed, for various technical reasons. The solid portion, containing principally stearic acid, is used in making candles. The waste portions of the extracted fats are worked into gas, by dry distillation. A quite pure wool grease, consisting of cholesterin compounds, is well known under the name of lanoline, and is used as a basis for healing salves and in cosmetic preparations.—Technische Rundschau, Berlin.

A MODERN TESTING PLANT FOR GASOLINE AUTOMOBILE MOTORS.*

By DR. ALFRED GRADENWITZ.

THE testing plant recently installed at the Berlin works of the Adler Fahrradwerke is interesting on account of the excellent arrangements provided for ventilating and for the safe storage and handling of the fuel.

This plant was constructed with a view of testing thoroughly each day a certain number of motors before mounting them upon the chassis for which they are intended. These tests would result in the room being rapidly filled with considerable quantities of gases and vapors, unless efficient ventilation was provided. For this purpose the Adler Fahrradwerke constructed a ventilation plant of such efficiency as to renew about forty times in the course of an hour the whole amount of air contained in the hall.

The plant includes three tubes terminating in a general collecting pipe which is connected to an exhaust blower driven by an electric motor. One of the exhausting tubes reaches nearly to the floor of the work room, whence it carries away the heavy gasoline gases, while the other two tubes start at the level of the heads of the workmen.

Each of the two testing floors is provided with one such exhaustion plant comprising three tubes, the amount of discharged air being susceptible of regulation. As regards the storage and use of the gasoline in the experimental station, the Martini-Hüneke system has been adopted. This excludes any danger of explosion by storing the gasoline underground outside the room.

If the atmospheric air be exhausted from the gasoline tank and replaced by a non-explosive gas, e. g., carbonic acid under pressure, it will be readily understood that the gasoline will no longer be able to form any explosive mixtures with air. As fast as the gasoline is discharged from the main tank into the testing rooms for the carbureter supply, the compressed carbonic acid will be simultaneously admitted into the latter.

Should the carbonic acid escape in the case of an outside fire or damage to the piping, the gasoline would be returned from all the pipes into the main tank, and the slight pressure of 3 or 4 pounds to the square inch, under which the carbonic acid had been forced through the pipes, would be immediately stopped.

A diagrammatic view of the apparatus is shown in Fig. 2. From the reservoir, *a*, the carbonic acid, after the gas pressure has been reduced by means of a valve, will penetrate into the underground storage reservoir, *b*, which is filled with 2,000 liters of gasoline, and will force the latter through the tubes, *c d*, to the two distributing valves, *e* and *f*. By opening the valve *g*, after connection has been made with a barrel or tank, *i*, reservoir *b* may be refilled. The portable tank, *a*, is at the same time filled with the carbonic acid removed from the reservoir, *b*, so as to exclude the possibility of any dangerous explosible gas mixtures being formed there owing to the presence of air. A mercury safety valve, *k*, serves to check the pressure-reducing valve and to remove any excess of pressure from the carbonic acid.

Special arrangements have been made to exclude any danger arising from a breakage of the pipes or valves filled with gasoline. The pipe, *c*, Fig. 3, through which the gasoline is discharged from the tank, *a*, is surrounded by a sleeve, *d*, beginning at the cover of the reservoir, and connected with the gas pressure compartment, *e*, of the latter, through a pipe, *f*. In case of breakage three things will be possible, as either the tube, *c*, or the tube, *d*, alone, or both tubes may be damaged simultaneously. The first and second cases will obviously give rise to no danger, as the liquid will be retained in one of the tubes, while in the third case the gas pressure from the reservoir is immediately discharged through the breakage in the sleeve, *d*, so that as the pressure is removed from the fuel, the latter will not be forced through the break.

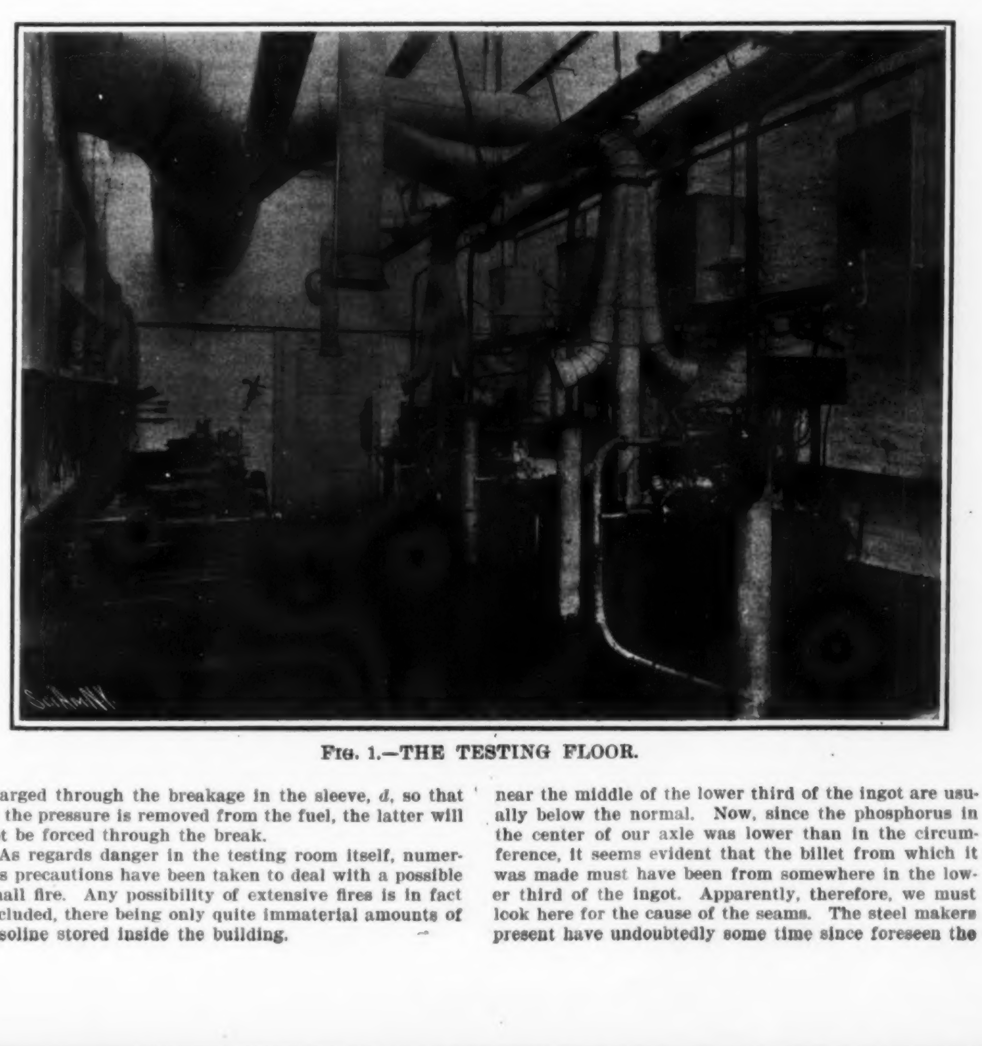


FIG. 1.—THE TESTING FLOOR.

As regards danger in the testing room itself, numerous precautions have been taken to deal with a possible small fire. Any possibility of extensive fires is in fact excluded, there being only quite immaterial amounts of gasoline stored inside the building.

In order to protect the operators of the motors against the objectionable noise of the high-pressure exhaust gases, noise damping devices have been arranged, terminating in a general collecting tube through which the exhaust gases are immediately carried above the roof.

The whole plant is constructed on the shed system. The floor is coated with a substantial layer of cement on top of which wooden grates are arranged, to protect the men against moisture. The building is lighted by electricity and heated from a central plant. The precautions and arrangements taken and made will be found efficient in excluding any accidents or diseases, even with the difficult operation entailed by the working of such automobile testing plants.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

PROBLEM OF A BROKEN AXLE.

WE recently saw a broken steel car axle. The break occurred 10 or 12 inches from the end of the axle. On examining both ends there was some appearance of seams, not radial, but rather in a sense irregularly parallel to the circumference. These seams suggested that probably the axle was made from a billet coming from somewhere near the top of the ingot and that the seams were in some way connected with the pipe. It was reasoned that if this were true an analysis of the metal from the surface and from the center of the cross section of the axle would show segregation, and that if, for example, much higher phosphorus were found in the center than at the circumference it would almost be a demonstration of the location of the billet. Of course, the whole object of the study was to see if any information could be obtained that would prevent the acceptance of such bad axles in the future. It should be mentioned that the broken-off piece was sawed in two lengthwise and that when this was done from one of the halves a core amounting to about a third of the cross sectional area actually fell out, showing that the seam indications at the end were genuine and that the seam did actually exist. The analysis above referred to was made, and to our astonishment showed lower phosphorus in the center than in the circumference. This seemed to settle the question as to the relation between the seam and the pipe, and indeed we regarded it as conclusive evidence that the billet from which this axle was made was not taken too high up in the ingot, but it left unsettled the cause of the seam.

Perhaps, however, a few words further on certain well-known phenomena in steel metallurgy will help us in clearing up the point: It is obvious that if in a big ingot a portion of it contains more than the normal amount of phosphorus, carbon, or sulphur, as is actually the fact in the case of segregation, it must follow that there will be parts of the ingot which will contain less than the normal amounts of these constituents. It is generally assumed that the outside of a forging like an axle gives very close to the normal analysis of the steel, since from the method of manufacture this outer metal was near the surface of the ingot when the metal was cast, and consequently cooled too quickly to permit perceptible segregation. Also, if we are right, the analysis of borings taken from different parts of the inner face of an ingot sawed in two lengthwise for the purpose shows that phosphorus, carbon, and sulphur near the middle of the lower third of the ingot are usually below the normal. Now, since the phosphorus in the center of our axle was lower than in the circumference, it seems evident that the billet from which it was made must have been from somewhere in the lower third of the ingot. Apparently, therefore, we must look here for the cause of the seams. The steel makers present have undoubtedly some time since foreseen the

cause of the difficulty with this axle. For the benefit of the others we may say that seamy bottoms of ingots are now usually explained by wet or insufficiently dried bottoms of ingot molds. The steam or other volatile material generated by the heat of the molten metal can apparently only escape up through the molten metal itself, forming a seam which the subsequent treatment does not weld up.—From a paper by Charles R. Dudley.

SPECIFICATIONS OF MATERIAL USED IN HIGH-SPEED AUTOMOBILE AND MOTOR-BOAT ENGINES.

By THOMAS J. FAY, E.E.

IN the early days of motor-boat building, critics were wont to say that automobile builders could not build motor boats; but these same critics are now busy trying automobile methods, for as one might reasonably suppose, a good motor such as is demanded in automobile work does not become a bad motor simply because it is placed on girders in a motor boat.

As a matter of fact, boat building is a fine art understood by thousands of skilled men and hundreds of naval architects, so that the building of a hull is easily accomplished, given suitable material.

Motors, however, are quite new as yet, especially the kind of motors that must be depended upon to survive in service, and do the required work under satisfactory conditions and for a length of time worth while taking into account.

Any one can build a motor, and for that matter, the fact of its having been built by anybody would not prevent its operating in service. But to build motors that will deliver say 30 horse-power in continuous service month in and month out within a weight of less than 500 pounds for the motor complete, is entirely another matter.

The motors to be used in the twin-screw boat illustrated in the current SCIENTIFIC AMERICAN are claimed to be of that character, and it is a reasonable expectation that either one of them would run the boat all summer with never a service interruption. Moreover, a higher speed and double assurance of continued good service will surely follow the use of two such motors.

The reason why these motors are likely to serve thoroughly well in practice is wholly a matter of design and of the materials of their construction; for in the construction of these motors, only "specification" materials of the highest order are given consideration.

With a view to a more specific statement of facts, reference will be made herein to the exact qualities of the materials used in the motors of this boat, as follows:

Table I. refers to the crankshafts of nickel-chrome steel, the strength of which is marvelous as compared with the ability of any carbon-steel product possible to secure.

Table II. shows a test of the finest acid open-hearth carbon steel possible to secure by resorting to special heats; and by comparing the two an insight will be gained by which to gage the fine qualities of the nickel-chrome steel crankshafts actually employed in these engines.

For the piston pins, which are very important parts in motors of great power per pound of weight, Table III. will expose the qualities of the material. This nickel-chrome steel is the same as is employed in making the famous Krupp guns.

Table IV. represents nickel-chrome steel for gears of the substantially unbreakable sort, such as must be used in motor-boat gears to serve in a thoroughly satisfactory manner.

The connecting shafts and other important parts are of still another grade of nickel-chrome steel, as shown in Table V., so that it is proper to say all important transmission parts are of the finest alloy steel possible to secure, either in America or abroad.

In the early days of the motor car and the motor boat as well, the foreign builders were wont to talk about their superior products; and for some reason not at first plain to us, these did have qualities that gave the foreigners a substantial lead. The Smith & Mabley Company, as importers of the well-known makes of foreign products, realized that something was amiss, and as a result of a thorough investigation it was found that the foreign products were made of "alloy steel." In due course these same grades of steel were imported and put into Simplex motors, which accounts for their unexceptionable endurance. The matter was put up to the American mills, with the result that to-day the same grades of material are to be had at will in America as well as from France and Germany.

TABLE I.—CRANK SHAFT.

Chemical Composition.

Carbon	0.25
Nickel	4.40
Chromium	1.53
Silicon	0.24
Sulphur	0.012
Phosphorus	0.013
Manganese	0.73

Physical Properties.

Tensile strength in pounds per square inch	154,400
Elastic limit in pounds per square inch	133,300
Elongation taken in 3 inches, per cent	11
Reduction of area, per cent	25

Test specimen cut from finished crank shaft.

Treatment.

Oil tempered at 900 deg. C. and annealed to 570 deg. C.

Process.

Furnished by the mill in slabs of rectangular section and cut to size from the solid.

Pins are ground to + or — 0.001, making crank shafts interchangeable and obviating elliptical formations.

TABLE II.—SPECIFICATION OF ACID OPEN-HEARTH STEEL FOR CRANK SHAFTS.

Chemical Composition.

Carbon	0.28
Silicon	Low
Sulphur	0.019
Phosphorus	0.023
Manganese	0.50

Physical Properties.

Tensile strength in pounds per square inch	85,000
Elastic limit in pounds per square inch	66,000
Elongation taken in 2 inches, per cent	24.5
Reduction of area, per cent	63.3

Fracture, silky.

Treatment.

Acid open-hearth process, pickled and annealed.

Note.—Not good enough for high-power motor service.

TABLE III.—PISTON PINS.

Chemical Composition.

Carbon	0.31
Nickel	3.30
Chromium	1.40
Silicon	0.26
Sulphur	0.028
Phosphorus	0.015
Manganese	0.41

Physical Properties.

Tensile strength in pounds per square inch	233,000
Elastic limit in pounds per square inch	221,000
Elongation taken in 2 inches, per cent	6
Reduction of area in per cent	40

Treatment.

Given physical properties, result of cementing and annealing.

Process.

Turned to rough size from natural bar, holes drilled, and after treatment, is ground to press fit dimensions.

In some cases treated government nickel steel is used.

TABLE IV.—TRANSMISSION GEARS.

Chemical Composition.

Carbon	0.238
Nickel	3.38
Chromium	1.87
Silicon	0.183
Sulphur	0.026
Phosphorus	0.025
Manganese	0.350

Physical Properties.

Tensile strength in pounds per square inch	123,800
Elastic limit in pounds per square inch	80,000
Elongation taken in 8 inches, per cent	10
Reduction of area in per cent	53.2

Values somewhat altered by subsequent treatment. Improved.

Diameter of test proof	0.767

Process.

Gear blanks are forged from convenient sizes of mill bars and annealed.

After blanks are machined and teeth cut, gears are treated, thus making the armor glass hard, and the core of great strength.

TABLE V.—CONNECTING SHAFTS.

Chemical Composition.

Carbon	0.30
Nickel	3.40
Chromium	1.50
Silicon	0.25
Sulphur	0.026
Phosphorus	0.014
Manganese	0.45

Physical Properties.

Tensile strength in pounds per square inch	120,000
Elastic limit in pounds per square inch	100,500
Elongation taken in 2 inches, per cent	16
Reduction in area in per cent	67

Treatment.

Used as received from mill, unless forged for flanges, in which event annealing at 570 deg. C. is resorted to.

Process.

Forged within definite exact limitation of temperature, annealed, roughed, and ground to size.

STEEL FOR REINFORCED CONCRETE.*

By A. L. JOHNSON, M.Am.Soc.C.E.

THE history of the origin of reinforced concrete has been published so often that the speaker will not enter into this part of the subject further than to say that he thinks too little credit has been given to Thaddeus Hyatt, an American, for the work he did in the years 1876 and 1877 in England. He made numerous tests of reinforced concrete beams at Kirkaldy's laboratory, reinforced with bars of different patterns and arrangements, developing at this early date the advantages of stirrups, of having them connected to the bar, of bending bars up at the ends for shearing provision in short beams, and in a general way the advantage of a mechanical bond, though his investigations here did not enable him to learn the criteria for differentiating the efficient from the non-efficient.

Up to the time of Hyatt very little work in reinforced concrete had been done abroad, other than in tanks, vases, pots, etc., in which the section was entirely in tension, and in which, therefore, there was little tendency for different movement on the part of the metal and the concrete, such as occurs in reinforced concrete beams. Neither had there been anything of consequence in the United States, about the only instance now known being a building constructed entirely of reinforced concrete by Ward in 1875, in the State of New York.

Ransome made some experiments in San Francisco on reinforced concrete beams, and on September 16, 1884, received a United States patent on a floor construction of concrete reinforced with square bars twisted, claiming as advantages over plain material an increase in tensile strength and a more secure bond. Later, he applied for and secured a patent on a triangular twisted bar, the contention for patentability being that this bar would not split the concrete ribs in which the bar was embedded, owing to the deeper cupping that would be obtained in the triangular type. Mr. Ransome's theory of the splitting action noticed is explained in the patent as follows:

Assuming a tee beam, or ribbed floor construction, in which the rib is reinforced with a steel bar, when the floor is loaded, the bar being bent up at the ends, it is as if the rib were held up by the bar, or sitting on the bar. If the floor is loaded to, say, 400 pounds per square foot, and the ribs are, say, 3 feet apart, then there is a vertical load of 1,200 pounds on top of the rib for each foot of length. Hence, the rib acts as a column, being supported on the bar at the bottom. As the bar is narrow, there is a tendency for the concrete to flow each side of the bar, or, in other words, there is a movement of the concrete above the bar, cross-wise of same. In a plain bar there would be no obstruction to the movement. In the square twisted bar there was not, according to Mr. Ransome, sufficient obstruction to the movement, as the cupping was not sufficiently deep. Hence the superiority of the triangular type.

The above theory was, of course, fallacious, and the type never came into commercial use. The vertical load on the rib for any given length is carried by vertical shear in the concrete, and the rib is not acting as a column at all. If it were, in the case mentioned where the rib carried 1,200 pounds per lineal foot, supposing the rib to be 4 inches, this would only give a compressive stress in the rib of 25 pounds per square inch, and would be too small to be noticeable even if many times this amount.

The ribs do not act as columns, but as beams, lengthening on the bottom and shortening on top, and it is the movement of the concrete lengthwise of the bar which the bar must be calculated to resist, and it is in this resistance that it begins to help carry the load and become an integral part of the structure. To offer reliable and satisfactory resistance to this movement of the surrounding concrete along the bar, it is necessary for the bar to have on its surface projections, or depressions, the sides of which are nearly at right angles to the direction of the movement, which is to say, to the bar itself. It is not necessary that the sides of these ribs or depressions should be exactly at right angles to the bar to develop this efficiency, however, it being possible to vary therefrom an amount equal to the angle of friction between the concrete and the metal, which, on the average, will be between 30 and 45 degrees. But if the surfaces against which the concrete presses are nearly parallel to the direction of the movement, we have the same action as when an ax is forced into a block of wood, a very heavy splitting component resulting, which may be many times as great as the direct force itself, similar to the action of a toggle joint.

Of course, this splitting action is of little effect until after the so-called adhesion of the concrete to the surface of the metal has been overcome. This adhesion is not really adhesion at all in the sense that two pieces of wood may be made to adhere to each other by means of glue. The appellation has been given to the resistance of a bar against withdrawal from a block of concrete. As a matter of fact, this resistance is made up of two parts, friction and a mechanical bond caused by the entering of the cement particles into microscopical pores on the surface of the metal, which particles have to be sheared off in withdrawing the bar. For short depths of imbedment these two forces amount to about 500 pounds per square inch of bar surface for bars of ordinary mill surface and for good concrete, where perfect union exists between the cement and the metal. Of this, friction contributes about 25 pounds per square inch, the remaining 475 being due to the mechanical bond. There is therefore no reason in advocates of plain bar reinforcement decrying mechanical bond, inasmuch as the plain bar has really no value not contributed by this same quality. The bond, it is true, is of a microscopical nature, but nevertheless its value is considerable, and if it would remain intact we could design and execute reliable concrete structures with plain bar reinforcement.

There are a number of things, however, tending to impair a bond of this nature, among which we may mention the following:

1. Shocks and vibrations continued through years of service are liable to injure, if not wholly destroy, the bond, and have done it in cases under the speaker's own personal observation.

2. Where the concrete is continually wet, the adhesion will be cut down from 50 to 60 per cent in less than one year, as indicated by the experiments of Breuillie.

3. The development of the working stress in the metal slightly stretches same, and the cross section is therefore slightly reduced. Suppose the metal has a working stress of 15,000 pounds per square inch, then the proportionate elongation is 0.0005, and the decrease in the

* Paper read before the Cement Users' Association.

diameter is, with practical exactness, one half this, or 0.00025, a quantity which, though small, could be readily measured by an ordinary micrometer, and certainly is far from microscopical.

The advisability of reinforcing bar with a more positive grip on the concrete than that afforded by the roughness of the mill surface of a plain bar, which is, of course, very slight, is not merely due to the necessity of maintaining continuously the strength of the beam, but also to the necessity of keeping the bars from being exposed to the atmosphere.

We know, now, that in a reinforced concrete beam cracks begin to form in the concrete on the tension side, at an elongation which gives a stress of from 12,000 to 15,000 pounds per square inch in the bars, which is at just about, or even a little below, the working stress usually employed. If plain bars are used these cracks will be far apart and correspondingly large, while if a bar is used having a positive grip on the concrete for every inch of bar, there can be no accumulation of cracking tendency for a considerable length, but there will be a great many cracks, mostly invisible to the naked eye, until the metal has passed its elastic limit. Such cracks will not be injurious, while the cracks that form with the plain bars might. They amounted to considerable in the tests made about five years ago by M. Considere, as a result of which he reported the wonderful stretchability of reinforced concrete that misled us all for some time. In these tests he bent the beam several hundred times, so that the tension fiber had been stretched from 15 to 20 times as much as plain concrete would stand, then cut a piece 8 inches long out of the middle surrounding the ¼-inch round rod that he used for the reinforcement, and then with great pains and labor cut the rod out of this 8-inch piece of rectangular section, leaving a hole through same from end to end. Now this concrete had been stretched, according to M. Considere, many times as much as plain concrete would endure, but instead of falling apart when the rod was finally gotten out, it was perfectly intact, and he put it on supports, loading it in the middle, and obtained as much carrying capacity as he could have secured with the same kind of concrete which had never been subjected to such severe usage. This seems like proof positive of M. Considere's conclusion. But it developed later that he had taken this 8-inch specimen from between two cracks of considerable size, and that while the rod had undoubtedly stretched as much as assumed the surrounding concrete had not, the end sections slipping back and relieving the concrete. In other words, there was a slip between the rod and the concrete. If the rod he used had been a rod of mechanical bond, giving a good positive grip for every inch of its strength, he would not have had this slip between the rod and concrete.

The distance between cracks on the bottom of a reinforced concrete beam subject to uniform bending moment, may be discussed as follows:

Let d = spacing of bars in inches.

e = distance from center of bar to surface in inches.

ft = tensile strength of the concrete in pounds per square inch.

s = bonding value of bar in pounds per square inch of surface.

l = spacing of cracks in inches.

The cracks will come at such distance apart that the bond of the bar for the distance equals the tensile strength of the concrete immediately around the bar, having in this respect a close analogy to the distance apart of the shrinkage cracks in a retaining wall.

Then we have for a square bar,

$$deft = 4sl$$

$$\text{or } l = \frac{deft}{4s}$$

On plain bars with real smooth surface s has been found less than 100 pounds per square inch, though, as before stated, for the ordinary rolling mill surface, with careful imbedment, it has a value originally of about 500 pounds per square inch. Assuming for allowance for ordinary working conditions, and for reduction due to shrinkage of bar section, an average value of 250 pounds where there is no vibration of consequence, and where the concrete is not wet, as it would generally be in open-air work, we have

$$l = \frac{deft}{1000}$$

For a mechanical bond bar, such as the corrugated bar, for example, this value will be in the neighborhood of 750 pounds per square inch, a value also which will be practically permanent, and for this,

$$l = \frac{deft}{3000}$$

That is to say, the latter type would give cracks of only one-third the size that would be the case in the beam reinforced with plain bars, even under the best average conditions. In the case of open-air structures, subject to vibration for some years, the disproportion might be very much greater than this.

The speaker has often been asked the question, Why is it necessary to use bars of mechanical bond, when abroad, where their experience is much greater than ours, they use only plain material? The question is a very proper one, and requires an explanation. As before stated, it is only in beam work that the necessity for absolute bond between the concrete and the metal exists, and in this line of work the beginning was made in this country in 1882. These structures were intended for floors, and to carry people and loads of different kinds, and not vases, flower pots, etc., of which the foreign work up to that time mainly consisted, all of which was reinforced with plain material. For floors and beam work in general plain bars did not seem a rational material to use, just as a common sense proposition; and the speaker doubts very much whether, if the construction of such work had been presented first abroad, the foreign engineers would have considered the use of plain bars, either. The natural development would have been to have used a form of mechanical bond first, and later if investigation showed it feasible, come to the simpler and cheaper form of plain material.

A year ago last May the Prussian government specifications on reinforced concrete were issued, and they cut down the safe allowable working stress in adhesion to about 30 pounds per square inch, recommending at the same time mechanical bond whenever possible. The above restriction on the working stress in adhesion made it very expensive, and in many cases impossible to use plain material, so that the recommendation in favor of mechanical bond was scarcely necessary. In France, too, much greater care is now taken, the bars being bent up and down and around about in the effort to obtain a better anchorage, as well as to provide for shearing stresses.

In specifying bars for reinforcement, there are a few fundamental principles that should be observed. In the matter of elastic limit, the general proposition is that the elastic limit should be as high as is consistent with the ductility required by the case in hand, up to, say, 60,000 pounds per square inch. There is no object in having a higher elastic limit than this unless the modulus, too, could be raised, which is, at the present time, not feasible. Preference should be given to more bars of small section, rather than to few bars of large section, as it is desirable to have the metal well distributed through the stretching concrete area. The bars should not be painted. A slight film of rust is no injury at all, and will totally disappear after imbedment. But if the bars have been exposed long enough for scale to form, this must be removed before use.

In designing, the factor of safety should, generally speaking, be four at least, certainly never less than three, which is based upon the elastic limit. That is to say, the working stress for the actual loads should be only one-fourth of the elastic limit. Many of the municipal building laws are seriously in error in that particular. This will require about three-quarters of 1 per cent reinforcement for material having an elastic limit of 60,000 pounds per square inch, and 1 3-10 for metal having an elastic limit of from 30,000 to 35,000 pounds per square inch. These are the percentages required to develop the full strength of the section in bending. Short beams, having a ratio of height to span of more than one-twelfth, will have to have some of the bars turned up at the ends, where they are not required for moment, to take care of the shear. This bending is readily done on the job cold, unless the bars are exceptionally heavy in section.

ELECTRICAL CONDUCTIVITY AND REFLECTING POWER OF CARBON.

PROF. E. ASCHKINASS some time ago made certain observations on the reflective power of polished carbon fragments, obtaining remarkably high figures even in the case of moderately great wave lengths. In view of the simple relation between the electrical conductivity and the reflective power for infra-red rays, which has meanwhile been discovered by Hagen and Rubens, the author recently resumed his experiments, an account of which is found in Annalen der Physik, No. 12.

From his observations it is inferred that the reflective power of carbon nearly throughout its spectrum, is determined almost entirely by the electrical conductivity. It is further shown that conductive carbon in the infra-red does not show the least analogy to what is called a "black" or even a gray body. This fact may be of some importance in the problem of the economy of certain illuminants. In illuminating flame reflection, it is true, it will not play an appreciable part, the carbon there being in an extremely finely distributed state. The case of flame arcs and especially of carbon filament incandescent lamps is, however, quite different, as reflection there plays an undoubtedly important part.

Prof. Aschkinass a short time ago showed that the laws of heat emission of bare metals were largely determined by their electrical conductivity, metals being for instance blackened more and more with increasing temperatures in the infra-red spectrum if their resistances were increased with rising temperatures. Now, the resistance of carbon is known to decrease with increasing temperature. Reflection will accordingly become the more intense as the temperature rises, so far as it depends on conductivity, and the economy of an illuminant including reflecting carbon will probably increase with rising temperatures at even higher rate than that of an absolutely black body.

TRANSMISSION OF ELECTRICAL ENERGY FROM SWEDEN TO DENMARK.

BOTH Sweden and Norway have doubtless an industrial future before them owing to the extensive water power available in both these countries, which makes them exceedingly suitable for the installation and operation of electrical power stations. Some plants utilizing the power of waterfalls are either in operation or being contemplated; some of these are intended to supply whole cities with electrical light and power derived from comparatively distant waterfalls. According to a recent notice in the Vossische Zeitung it is, for instance, proposed in the city of Lund to utilize certain waterfalls of the Laga River to supply with electricity not only that city, but quite a number of others in the south of Sweden. It will be interesting to learn that a Danish syndicate intends purchasing the same falls, with a view to utilizing them as a source of electrical power. The Laga River, coming from the Smaaland Highlands, traverses the province of Halland for a distance of 23 miles, terminating near Laholm. This river forms in its course two large waterfalls—the Magefos, about 25 feet high, and the Katefos, about 30 feet high. The Danish syndicate, it is stated, will install electrical power stations near these waterfalls, whence the electricity is to be transmitted by cables to the south Swedish coast city Helsingborg and thence by submarine cable through the Oeresund to Denmark. This interesting project of transmitting electrical energy through submarine cables from one country to another will be quite a novel development in the electrical industry.

CONTEMPORARY ELECTRICAL SCIENCE.*

RADIO-ACTIVITY OF BREATHING WELLS.—Gerlier has recently described a number of Swiss wells which alternately absorb and expire air in accordance with the state of barometric pressure. They equalize the atmospheric and subterranean pressures, but with some retardation owing to the slowness of the flow through the strata. The latter usually consist of coarse gravel. E. Sarasin has measured the radio-activity of air expired by one of these wells in a square in the village of Meyrin, near Geneva. He found a radio-activity about ten times that of ordinary air, positive charges being dissipated a little more rapidly than negative. The activity varied with the strength of the air current.—E. Sarasin, Physikalische Zeitschrift, October 26, 1905.

ANTI-VIBRATION SUSPENSION.—W. H. Julius, the inventor of the anti-vibration suspension which bears his name, points out that its principles are not yet sufficiently grasped by manufacturers. It must fulfill five conditions to be effective. The three wires of the suspension must be of equal length, equally loaded and perceptibly stretched. The center of gravity of the whole suspended body must be in the horizontal plane containing the bearing ends of the wires. Those parts of the apparatus whose freedom from disturbance is most important must be near the center of gravity. Vertical shocks must be eliminated by introducing a short length of spiral spring into each wire. And, lastly, the proper vibration of the suspended body must be damped by liquid immersion or cotton wool, mounted in the plane containing the center of gravity. If the apparatus on the suspension must be frequently handled it is best to have a clamping device. This consists of a triangular frame mounted on a table and surrounding the triangular plate of the suspension on all sides within 1 centimeter. A screw projects through each side of the frame, and when one of the screws is driven home it urges the suspension against the two others. The three screws then hold it until the manipulation is over.—W. H. Julius, Annalen der Physik, No. 11, 1905.

RARE ATMOSPHERIC GASES.—Dewar showed that charcoal at the temperature of liquid air possesses an extraordinarily high absorbing power for atmospheric gases, and used this property for discovering hydrogen, helium and neon in comparatively small quantities of air. S. Valentiner and R. Schmidt have now employed this same property for manufacturing neon, krypton and xenon for spectrum tubes. To obtain the neon, they collected a quantity of argon, which contains neon, and led it over cocoanut charcoal kept at the temperature of liquid air. In this manner they liberated the neon, and avoided any admixture of nitrogen. The pressure had to be low, not exceeding a few millimeters. To free the neon from traces of helium, they occluded it in pure charcoal at a somewhat higher pressure and drove it out again. They thus obtained spectroscopically pure neon. To obtain krypton and xenon, they used charcoal at —120 deg., which absorbs krypton and xenon completely, but only a little argon. They again eliminated the argon by connecting with a tube of charcoal in liquid air. Heating to —80 deg. liberated pure krypton. A similar differential method enabled the authors to eliminate the krypton and to obtain spectroscopically pure xenon at —15 deg.—Valentiner and Schmidt, Annalen der Physik, No. 11, 1905.

HEAT EVOLVED BY RADIUM.—Knut Angström has endeavored to get some decisive answer to the question as to whether the α, β and γ-rays of radium account for the heat evolved by it or not. He finds that the energy represented by these rays is but a very small part of the total energy evolved. Paschen, on the other hand, thought that the γ-rays represented more than half the total energy evolved, but since announcing that result he has found an unsuspected source of error in his experimental arrangement. Angström's new experiments were made with calorimeters of lead, copper and aluminium, constructed with walls 1 centimeter thick, so that in the case of lead the γ-rays are absorbed by the walls. Two such calorimeters were used in each case, one containing a tube with 87 milligrammes of pure radium bromide, the other a manganin coil heated by a known current and producing the same quantity of heat as the radium, the comparison being made by thermo-couples inserted in the calorimeter walls. No difference could be detected in the action of the various metals, and it must be concluded that the absorption of all the rays given out by the radium does not appreciably add to the heat received by the calorimeter. Hence the bulk of the energy given out must be in the form of radiant heat.—K. Angström, Physikalische Zeitschrift, October 26, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

WOOD DISTILLATION.

Wood distillation has been tried in this country so extensively of late, and has been brought so prominently to the attention of the Forest Service as a means of utilizing waste in lumbering, that a careful and thorough investigation is to be made by the Service, covering both what has been accomplished in this industry and what may be done to reduce it to more scientific principles and to place it upon a sound commercial basis. The various processes now in use will be studied and compared, as well as the resulting products and the uses to which they are or may be put.

To push this study to early and useful results with the least possible delay, Mr. Thomas W. Pritchard, a practical expert in wood distillation, has been engaged by the Forest Service to devote his entire time to the work. Mr. Pritchard, who is a trained chemist, has for several years been connected with successful distillation plants in the South. He has already begun his work with the Forest Service, and will at once communicate with the owners of wood-distillation plants throughout the country to first determine the degree of success to which the business has reached. He will then closely examine the methods which have resulted most successfully, and attempt to extend their use. He will pay particular attention to the extent to which lumbermen may adopt wood distillation as a means of turning into useful products the tops, slabs, and other waste of sawmills, which are often at present a total loss.

Destructive distillation consists in driving out all the liquid matters in the wood and collecting and condensing them afterward. Intense heat is employed, and the original form of the wood is changed chemically into various liquids and pure carbon. The wood is closely placed in a steel retort, with the doors tightly sealed, and fires are started in the furnace beneath.

In a few hours distillation begins. The liquids are driven from the wood, are changed to vapors, and pass off through a pipe at the top of the retort, which leads to a condenser or worm, immersed in water, where they are condensed in the order of their gravity. Again restored to liquid form, they then pass through the rest of the coil and run into collecting tanks. The gas, the lightest of the products, rises to the top of the coil and is piped off.

The liquid products are redistilled in a secondary still into the various oils and by-products. Thus, the thin, amber-colored oil, which is one of the products of the first distillation, is changed in the second still into wood spirit or turpentine, a light oil, and a heavy oil, the residuum being tar. This process, which is the one carried on at several successful plants, is only one of those which the Forest Service is to take up critically.

The outfit for a plant with a capacity of 100 cords of wood every thirty-six hours, which is as small as can be profitably handled, consists of a "battery," or two retorts holding 5 cords of wood each. These retorts are set in brickwork, about 50,000 bricks being required for a "battery." In addition are needed a coil or condenser of copper, a copper still of a capacity of 1,000 gallons, a second condenser, sufficient collecting and storing tanks, a boiler of not less than 10 horse-power, and pumps to handle the products. All piping should be, if possible, of copper, except after the second distillation, and the pumps should be brass-lined.

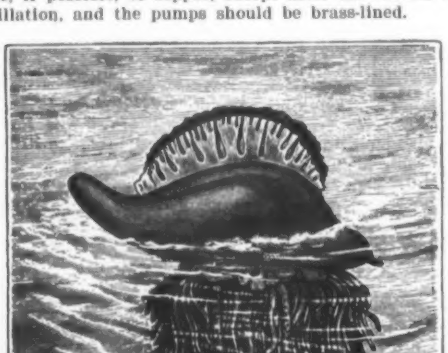


Fig. 1.—PHYSALIS (PHYSALIA PELAGICA) AFTER CUVIER.

From such a plant the yield should be approximately from 75 to 100 gallons of oil or tar per cord, and from 10 to 15 gallons of wood turpentine. There are also produced about 25 bushels of charcoal and pyroligneous acid in quantities about equal to the oil. The amount of products is in direct ratio to the resinous constituents in the raw material. The value of the products is variable. If properly made, the tar should bring the average market price of pine tar, and the spirits sell for from 15 to 5 cents below the market price of spirits of turpentine. If no tar is made, and oil is produced, the latter must be made into special preparations, such as wood preservatives, paints, stains, disinfectants, or any one of a dozen other products. The demand for wood creosote oil in the state in which it comes from the still is limited.

The application of wood distillation to the utilization of waste material both from the lumber mills and from the cut-over coniferous forests of the South, is beyond question. Any mill waste which is rich in resinous products can be used, and the very best results are obtained from the down timber and stumps in the cut-over pine forests. Most of the lumbermen have timber holdings which contain material suitable for distillation. The great sawmills of the Pacific coast have a large proportion of such material in the slabs which now have little or no use. By using the down timber in the woods the fire risk is greatly minimized, since any and all material suitable for wood distillation is necessarily of a most inflammable nature. In many cases even the roots as well as the stumps may be used for distillation, thus greatly lowering the cost of clearing land for agricultural purposes.

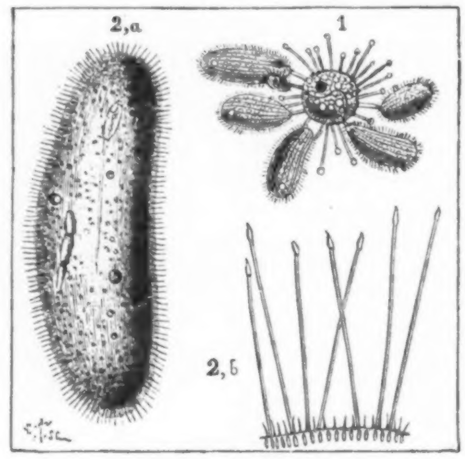


Fig. 3.—INFUSORIA.

1. *Sphærophrya magna* sucking five colpods and a *Cyclidium glaucoma*. 2a. *Plagyopyla fusca*. 2b. Trichocysts or poisonous arrows of the preceding.

VENOMOUS ANIMALS.

Venomous animals, as a general thing, excite a natural repulsion. Nevertheless, among those that secrete venom, there are many that are not only harmless, but useful to man, and if there are dangerous ones, such as snakes, that is due more to man's imprudence than to the viciousness of the reptile. The serpent surprised by the sudden presence of an awkward foot, responds by a somewhat abrupt but natural motion. It is a reflex of legitimate defense.

In all venomous animals the venom is in the first place a means of defense of the species against the attacks of stronger or more agile enemies; but in the majority of them it also has an inoffensive rôle, and this is the more important since the object of it is to procure for the aggressor the food necessary for its life by assuring the immobility and capture of its prey.

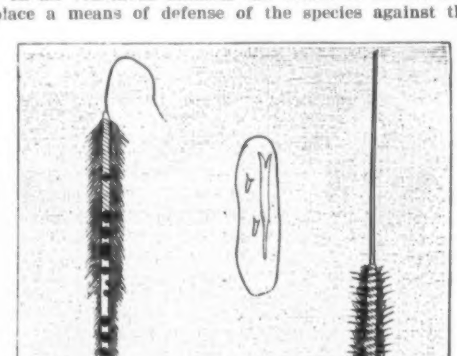


Fig. 2.—NÉMATOCYST OF CŒLENTÉRA.

In living beings everything is subordinated to the primordial need of feeding, and, in order to procure their food, animals employ means which vary according to the form and structure of their body. While the majority of carnivores possess the agility and strength necessary to capture and tear their prey, serpents, destitute of limbs and powerful jaws, await it and strike it in the shade. Moreover, the violence of the poison compensates largely for the absence of strength and agility, and is to the being that utilizes it a simple and rapid process. So, in the struggle for existence, the poison method is widespread. In almost all the zoological groups, we find species of which the sting or bite is venomous.

In the Protozoans even we find venomous species. The infusoria, as we know, exhibit an ovoid body covered with vibratile ciliæ, and a mouth surrounded with an armor of hooks and flagellæ which serves them as an offensive weapon for seizing other infusoria upon which they feed. In addition to this widely diffused type, there exist other species that crawl slowly in the crowd and discharge their poisoned weapon against the first. These venomous infusoria, which on account of the slowness of their motions are designated by the name of Acinetes (α privative, and κινητος, agitated) possess neither mouth nor vibratile ciliæ. Their body, composed of a mass of protoplasm, is limited by a thin cuticular membrane. What distinguishes them from other infusoria is the presence of numerous tentacles terminating in a sort of button. It might be thought at first sight that these were organs of locomotion; but such is not the case, for these tentacles exist on individuals that are fixed to the ground and completely immovable. Their use is entirely different. They serve for the capture of prey, as shown in Fig. 3, No. 1, which represents a *Sphærophrya magna* in the act of devouring six infusoria, five of which are larger than itself. It is curious to find that these beings, so agile in a normal state, rest thus fastened without reacting at the extremity of the very tenacious appendages. As soon as they have been touched by the terminal button they remain as if stupefied, and the acinetes empties them by means of its suckers. This is because the infusoria secretes a powerful poison that anæsthetizes and paralyzes. Other species of infusoria not only possess a venom, but also a special inoculating apparatus. Thus, the *Plagyopyla fusca* (Fig. 3, 2a and 2 b) possesses under its cuticle a considerable number of ovoid capsules called trichocysts containing both a dart and poison. When the animal is attacked or defends itself it contracts these capsules and projects poisoned arrows against the prey or the enemy. In order to see the various effects of the venom better, it is necessary to examine more perfect animals.

Cœlentera.—The fresh-water hydra is a well-known animal of which the body (Fig. 4) has the general form of a cylindrical worm, one extremity of which is fixed to the plant called duck's meat, while the other, slightly inflated, gives rise to slender filaments which are often very long, and, in the brown hydra, reach several inches. These threads, as delicate as those of a spider's web, constitute, but with a voluntary motion to boot, a capturing apparatus. The hydra throws these long tentacles out in all directions and entangles in them small animals, such as crustaceans, annelids and the larvæ of insects, then retracts them and draws the victims to its mouth, which is situated at the base of the tentacles. It thus captures a large number of individuals, for it is very voracious, and, when it is satiated, contracts its arms, remains motionless and digests. The whole operation takes place without the least struggle occurring. Scarcely has it been seized than the victim is rendered immovable and incapable of reaction. This can be explained only by the action of a powerful poison. There exists, in fact, upon the entire surface of the body, externally as well as internally, but particularly upon the arms, small capsules called nematocysts, capable of darting poisoned arrows. The use of the nematocysts assumes considerable importance among a certain number of other cœlentera, in which appear new organs specially designed for carrying arrows and darting them at their prey or their enemies.

The hydra, as we know, is reproduced by budding, the young ones remaining attached to their mother. It is a numerous family which remains united for some weeks, and which disperses when food becomes scarce, or the mother through exhaustion can no longer nourish her brood. If, instead of separating, the members of this family combined their efforts for the good of the community, we should see all the advantages of the social organization develop themselves. Such an evolution has been accomplished in a group of marine animals that form "animal colonies." The individuals of this group, which contains the corals, Medusæ and the Physalidæ (Fig. 1), are, in fact, formed by the union of a certain number of individuals adapted for different functions. Some of these individuals are transformed filaments (nematophores). They carry poisoned arrows, and have the special mission to perform of attacking prey and defending the community. Fishes and crustaceans are the most usual victims. Paralyzed by the arrows, they fall motionless into the inextricable tangle of the fishing filaments and are gradually reduced by the digestive juices into a thick *bouillie* into which the animal greedily plunges its suckers.

The weapon that produces such effects (Fig. 2) merits a few remarks. It is a hollow barbed arrow of which the stiff point, in penetrating the tissues, separates from the tube which it serves as a cover, and thus allows the venom to flow freely into the wound. Here the venom is in the interior of the weapon instead of being outside, as in the arrow of a savage. Besides, the arrow forms part of the quiver in which it is coiled like a spring in a state of rest. When the animal wishes to dart it, it presses its quiver. The filament turns back, distended by the venomous liquid and the whole is ejected by a mechanism analogous to

that of a cross-bow, actuated by special muscles. These organs are often accumulated in certain regions of the tentacle, on the surface of small longitudinal papillæ, where they are arranged as "urticating batteries" as in the Porpitæ (Fig. 5). When all these batteries are in position, they are capable of darting millions of projectiles at the enemy.

The arrow of the polyps, a perfect weapon of defense and attack, has still another function. It is widely distributed in the folds of the stomach where the venom serves to digest the prey and is almost its sole use in a large number of the Corallidæ. One of the best known types of these is the red coral (*Corallium rubrum*). It is formed of a ramified calcareous skeleton the surface of which contains a large number of pits in which at the least danger the members of the colony seek safety.

They have the form of a tubular corolla of which the fine white petals detach themselves sharply from the red of the stem. When the water is calm, they expand like so many flowers. Attracted by the brilliancy of the corollas, the pygmies of the sea approach the immovable flower without suspicion, when the petals immediately close upon the audacious animal that has touched them. The carnivorous flower after seizing its victim retreats within its calyx to digest at leisure, and it is then that the venomous capsules accumulated in the folds of the stomach come into play.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

FOOD IN ITS RELATION TO TEETH, THEIR SOCKETS AND ADJACENT STRUCTURES.*

By A. W. HARLAN, M.D., D.D.S., New York.

THE food question and the dietary question have received, during the past few years, a great impetus through the experiments of the United States government in feeding preserved foods † to a certain number of volunteers, and the additional experiments conducted at Yale College by Prof. Chittenden, with a detachment of United States soldiers, for a period of six months, a squad of Yale athletic students, and several of the professors and teachers, including Prof. Chittenden himself.

These experiments were not conducted to prove anything more than to determine how the equilibrium of the body might be maintained on a much smaller diet than that called for by the generally accepted figures upon this subject. With the exception of the teachers, most, if not all, of the men were under thirty years of age. They were under constant supervision and the food was all accurately weighed, analyzed, and then eaten with absolute regularity. The excretions were all collected separately, analyzed and accounted for. This great care disclosed that a smaller quantity of protein was needed and consumed than the tables of Voit, Duckworth, and others say is necessary. None of these men did much manual labor during the experiments, save the work in the gymnasium, and the care of their rooms, with one hour of enforced exercise. At first nearly all of them lost in weight, but after a few weeks the reduced weight was maintained with great regularity. None of the men were ill, and they did not complain of lack of variety in their food, nor did they seem to miss the larger quantity of food formerly consumed.

These experiments proved that it is not necessary to consume so much food, especially of the proteids. It did not prove, however, that vegetables or a vegetarian diet is best for man. These experiments have no direct bearing upon the question before us because we are arguing for use of the teeth upon food that requires for its thorough digestion and assimilation perfect mastication. Accompanying this paper will be found tables of food values.

A man's food, if he expects to accomplish much mentally or physically, must be chosen for definite purposes—to repair waste and maintain his muscles, nerves, bones, and blood in the best possible condition to enable him to think and act to his fullest brain capacity. In consequence of the needs of the matured physical organism, that food is best for man which will not distress him in his mind nor be revolting to his taste. It must be chosen for bodily repair as well as exercise of the jaws and teeth, and the muscles concerned in the masticatory and digestive acts. Foods or foodstuffs that are liquid or semi-liquid are not intended for any persons except infants and invalids, and edentulous persons unable to wear artificial teeth, and even then only for limited periods.

"Nature produces no food that should be swallowed without mastication, when eaten in its elementary state. She produces no soup trees, gravy vines, mush plants nor cook stoves. Elementary food must be masticated." (This does not refer to milk.)—Christian.

Milk even is not the ideal diet for a child above two years—most children need food that can be chewed and ground into a pulp.

"Nearly all foods (not milk or grape juice) thrust into the stomach without mastication do not excite a sufficient flow of gastric juice."—Pawlow.

"It is estimated, and perhaps within the limits of truth, that 500,000 infants die in this country every year through consumption of adulterated or unfit foods. Much spoiled grain, it is said, enters into the composition of many of the cereal foods, and the temptation to perpetrate fraud is as great here as in any other field of business activity."—Spach.

The question of food, and pure food for the many, is one of such importance that the daily press, legislatures, and Congress itself are all becoming active in search of it. Even the chefs of hotels and restaurants are discussing this question, and laws against food adulteration have been passed in many, if not all the States; and there is also a general law for the whole country now in effect, which is being enforced where malefactors can be detected and convicted. The rich and poor alike need good food, properly prepared, so that the whole nation will be improved both mentally and physically by the use of proper food.

This profession cannot neglect such a vital question,

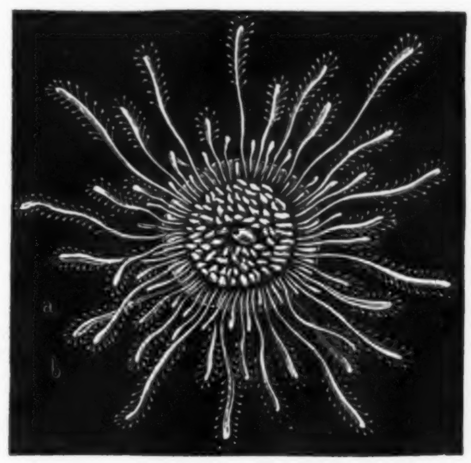


FIG. 5.—PORPITA MEDITERRANEA SEEN FROM BENEATH.

a. Tentacles carrying batteries of urticating buttons.

and the forty thousand dentists who come in contact with two or three hundred thousand people daily must be the teachers of dietetics and everything connected therewith. The physician sees the infant from birth to three or four years of age much oftener than the dentist, but after that age is reached the dentist has nearly supreme control of the organs of mastication, and he would be neglecting his opportunities who did not sufficiently impress parents and children with the necessity—the absolute necessity for use of the teeth, and guide them in the selection of food that must be chewed and ground between the teeth before it is swallowed.

From the initial moment when man enters the world he is in need of food. For a few months mother's milk or cow's milk suffices, but a time soon comes when there are teeth in the jaws, and the nature of the food is changed to give them exercise and thereby aid digestion.

"Soft, mushy foods are responsible for the woeful decay of teeth, which is such a conspicuous mark of civilized man. Nature will not keep alive nor produce, generation after generation, any part of the anatomy that is not used. Her system of economy is perfect."—Christian.

Dr. E. A. Bogue says: "Civilization indulges in soft food, cooked until it is softer."

"Nature is a perfect economist. If the teeth are not used, she will refuse to keep them in repair; she will allow them to decay. She presumes that you do not need them because you have refused to put them to that use for which they were created. So long as people subsist upon soft, cooked, mushy foods, they cannot expect to have good teeth. This is one of the greatest arguments against the baneful habit of cooking and in favor of elementary foods."—Christian.

All young animals as well as children are fed upon milk, but as soon as they erupt teeth the diet should be changed to give exercise to the teeth and furnish masticatory exercise for the muscles of the stomach, as well as those of the alimentary tract.*

Man in his primitive state subsisted on flesh, fish, and foods which he found in roots, grains, and fruits. See history of the inhabitants of Polynesia, the Ladrones, Carolines, Friendly, Tongalese, New Guinea, Hawaii, Fiji, Gilbert, Marshall, Iceland, Greenland, etc. Even the monkey in a natural state eats first, animal food, then nuts, roots, and vegetables, according to the productiveness of the country of his habitation.

"When food is taken into the mouth the digestive process has its beginning in the mastication, or grinding and crushing, of the food by the teeth. To this end it is essential, first of all, that the teeth should be competent to perform their office, or we shall find that the subsequent offices will be interfered with. *Teeth must be sound, free from decay and from decomposing matter.*"—Hoy.

Perfect mastication is the surest means of avoiding the habit of over-eating, which is so disastrous to the health and so common among civilized people.

"If physicians could be got to realize the importance of providing the jaws, teeth, and the muscular coats of the digestive tract with adequate work, an untold amount of disease and suffering would be averted."—Campbell.

"Food must contain a certain and considerable amount of indigestible, innutritious, and unabsorbable matter."—Wallace.

In other words, fodder or husk to clear out the intestinal tract.

"Before primeval man had learned to cook he subsisted largely on raw grains, seeds, and roots containing starch. The jaws and teeth were highly developed, and mastication and insalivation were very important functions in food absorption. The mouth was then a veritable mill for grinding and comminuting these substances, and in a certain sense the action of the saliva with its diastase took the place of cooking, the raw starch being changed to soluble starch, dextrin, and certain forms of sugar. At the present day, however, the digestion of starch begins in the kitchen, for the greater portion of starchy food is cooked when served, and is thereby rendered so soft that mastication and insalivation are much less needed. It would, however, be a great mistake to neglect to chew these foods, for deliberation in eating is a great advantage."—Pattee.

Starch is of great practical use, for it is more digestible than fat, and when combined with protein it appears to aid the digestibility of the latter; the starch which escapes digestion in the stomach ferments in the intestines, forming certain acids. This acid fermentation is known to check the putrefaction of the undigested protein and *vice versa*. This is the true reason of the utility of a mixed diet and the supposed needs of the organism.

"On entering the mouth the food, if solid, comes under the action of the teeth, by which it is cut, torn, bruised, and ground by a finely mechanical action until the complete insalivation."—Smith.

It is not necessary to chew olive oil or butter fat, as there is no mouth or stomach digestion, such substances being emulsified so that they can enter the circulation with little or no change.

Some governments in constituting dietaries for sol-

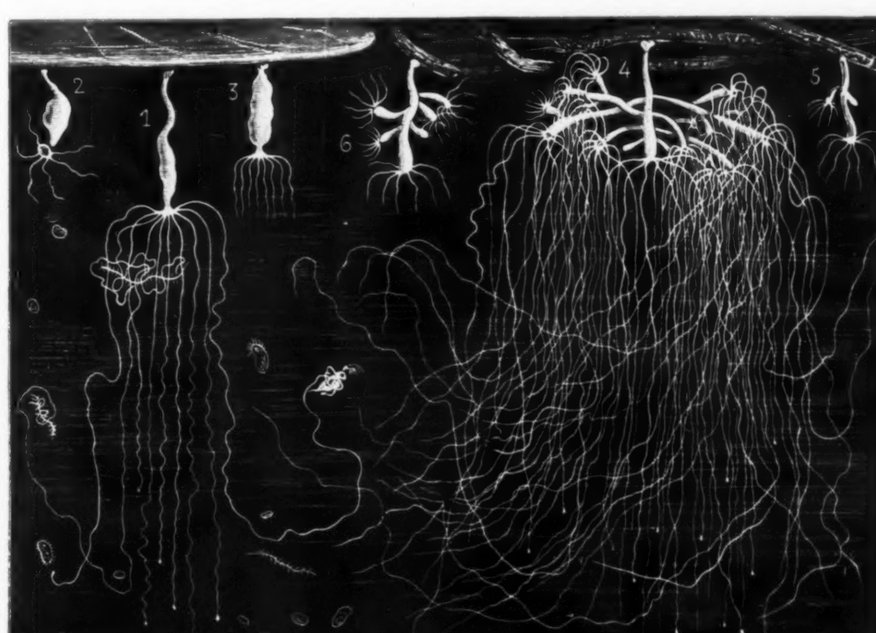


FIG. 4.—FRESH-WATER HYDRAS FIXED TO THE UNDER SURFACE OF AQUATIC PLANTS.

1. Brown hydra which has seized two Naides and a Daphnea. 2. Another half contracted and gorged with food. 3. Gray hydra digesting. 4. Gray hydra which was abundantly fed in captivity and which has produced a colony of nineteen buds. 5. Hydra budding. 6. Hydra which was taken in water very rich in infusoria and small crustaceans, and which has reached a maximum of fecundity.

* Read before the New Jersey State Dental Society.

† Preserved with borax or boric acid.

* Animals are weaned by force if necessary.

diers in times of peace make them only barely sufficient to sustain life, forgetting that when the soldier goes into the field he needs teeth, eyes, nails, bowels, and, in fact, all the strength for necessitous endurance. Managers of prisons are guilty in this respect also. Sailors and marines do not fare so badly, as there is always a small surplus of tissue builders in their diet.

Dietaries must be based upon the theory that all organs of the body must be used. The cost of medical attendance, medicines, and nursing, and the loss of time of soldiers and prisoners, when ill from too little food, more than offsets the extra cost of additions to a correct dietary. Many times more care and attention is given to the feet than the teeth, stomach, and bowels. The teeth must have something to exercise upon, and the whole alimentary tract must receive cellulose and other indigestible fiber to produce regular and rhythmical movement of the bowels. Children above two years of age must have something innutritious to masticate to permit of symmetrical growth.

To say that a certain amount of food, properly masticated, will sustain life, is not enough. There must be a surplus to allow for miscalculation in quantity, change in labor, or climatic changes.

AVERAGE DAILY DIET OF THE PROFESSIONAL MAN, THE SOLDIER, AND THE ATHLETE.

PROFESSIONAL MAN.	Grams.	THE SOLDIER.	Grams.	THE ATHLETE.	Grams.
Coffee	175	Banana	141	Banana	94
Cream	22	Butter	55	Cream	150
Sugar	44	Sugar	80	Sugar	36
Iced tea	250	Cream	155	Coffee	450
Boiled potato	90	Bread	60	Wheat roll	83
Wheat gems	47	Coffee	450	Butter	29
Butter	20	Bread	21	Soup	150
Roast lamb	9	Soup	247	Farina croquette	100
Vanila eclare	47	Fried potato	222	Fried sweet potato	117
Lamb chop	32	String beans	65	String beans	75
Asparagus	40	Consomme	150	Syrup	50
Creamed potato	107	Bread	45	Bread	36
Bread	35	Spinach	200	Hamburg steak	53
Lettuce and orange salad	150	Potato	150	Potato	250
Cream cheese	12	Pie	103	Spinach	100
Crullers	21	(Three meals daily.)		Bread	55
				Apple Pie	142
Fuel value of food (in large calories)	1,434		2,676		2,886

AVERAGE DIETS APPROVED BY THE UNDERMENTIONED AUTHORS.

	Moleschott.	Ranke.	Forster.	Hultgren & Landergren.	Atwater.	Stockland.	Schmidt.	Voit.*	Gautier.†
	Grams								
Proteid	130	100	131	134	125	114	105	145	135
Carbohydrates	550	240	494	523	400	551	541	500	750
Fats	40	100	68	79	128	54	62	100	100
Fuel value (Calories)	3,160	2,324	3,195	3,436	3,315	3,229	3,236	3,574	3,876

It will be seen at a glance that these are from one-half to three-fifths larger than Chittenden's.

The feeding of an army is to-day a solved problem. As proof of this let me read: "The problem of feeding the Japanese forces is rendered very much easier by the composition of the rations, which do not include bread. The rations in 1900 were made up as follows—they are the same to-day, with a slight increase of meat: Rice, 900 grammes (100 grammes equals 3.2 ounces); fresh meat, 400 grammes, or 200 grammes of salt fish, or 300 grammes of dried fish (these quantities were increased by 70 grammes per day when the troops were on the march); fresh cabbage, 400 grammes, or 150 grammes of dried cabbage; tea, 15 grammes; vegetable sauce for seasoning the rice, 10 grammes; arrac, 20 centiliters. The commanding officer can order as extras 20 grammes of sugar per day and ten cigarettes and five eggs per week."—The Mail, London.

Other questions come into consideration of the methods of preparing foods.

Striking evidence was given before the Royal Commission on the ‡Care of the Feeble-Minded by Sir James Crichton Browne, the Lord Chancellor's Visitor in Lunacy.

Sir James said that there was reason to believe that 30 per cent of the population were still living in poverty and were ill-housed, ill-clothed, and under-fed—conditions which favored mental degeneration.

He felt that a large amount of mental defect was due to insufficient and improper feeding in infancy and childhood. Natural nursing had gone out of fashion, and many of the condensed milks and proprietary foods were quite unsuitable and harmful. Babies fed on them might look plump, but they were pale and flabby, and often suffered from rickets.

He believed that the effects of alcohol in the production of mental defects had been exaggerated, and did not believe that in the causation of more than 15 per cent of cases of "idiocy and feeble-mindedness had alcohol taken any part."

The witness added that the late Prof. Laycock, of Edinburgh University, used to divide idiots into two classes—poverty idiots and luxury idiots. In the case of the latter the causes of mental degeneracy were indolence and self-indulgence through many generations with "in and in" breeding.

The persons thus afflicted were called by Prof. Laycock "spoonbill" idiots, and he used to point out that they were the type represented in Punch as "aristocratic noodles."

In this connection read what Prof. Maxwell said in Asbury Park on July 5: "When I look upon the anæmic faces and undeveloped bodies that mark so many of the children of the tenements, when I read of the terrible ravages of tuberculosis in the same quarters, I cannot but think that the city should provide wholesome food at the lowest possible cost in public school kitchens. To lay the legal burden of learning upon children whose blood is impoverished and whose digestion is impaired by insufficient or unwholesome feeding is not in accord with the boasted altruism of an advanced civilization or with the divine command: Feed the hungry. Is this not also a subject for investigation by our national council?"

"Proprietary foods are the apparent cause in nearly all cases of infantile scurvy. The (real) cause is a destruction of the chemical composition of the blood."—Fruitnight.

* Soldier on active service.
† Workman—eight to ten hours per day.
‡ May 20.

FOOD VALUES WITH TABLES.

THE UNDERMENTIONED TABLES WERE COMPILED FROM ANALYSES IN THE AGRICULTURAL DEPARTMENT AT WASHINGTON, D. C.

Flesh Foods.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash or Mineral Salts.	Fuel Value per lb.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Calories.
Loin of beef, edible portion	....	70.8	24.6	3.7	....	1.3	615
Loin of beef, total	23.0	54.6	18.8	3.0	....	.9	475
Porterhouse steak, edible portion	....	60.0	21.9	20.4	....	1.0	1.270
Porterhouse steak, total	12.7	52.4	19.1	17.9	....	.8	1.110
Round steak cuts, edible portion	....	70.0	21.3	7.9	....	1.1	730
Round steak cuts, total	8.1	64.4	19.5	7.3	....	1.0	670
Loin of veal, edible portion	....	73.3	20.4	5.6	....	1.2	615
Loin of veal, total	22.0	57.1	15.9	4.4	....	.9	480
Shoulder of veal, edible portion	....	73.4	20.7	4.6	....	1.3	580
Shoulder of veal, total	18.3	59.9	16.9	3.9	....	1.0	480
Leg of lamb, edible portion	....	63.9	19.2	16.5	....	1.1	1.055
Leg of lamb, total	17.4	52.9	15.9	13.6	....	.9	870
Leg of mutton, edible portion	....	67.4	19.8	12.4	....	1.1	890
Leg of mutton, total	16.8	56.1	16.5	10.3	....	.9	740
Pork ham, edible portion	....	60.0	25.0	14.4	....	1.3	1.075
Pork ham, total	.9	50.4	24.8	14.2	....	1.3	1.060
Pork head, edible portion	....	45.3	13.4	41.3	....	.7	1.980
Pork head, total	68.4	13.8	4.1	13.8	....	.2	660
Pork loin (chops), edible portion	....	52.0	16.6	30.1	....	1.0	1.580
Pork loin (chops), total	19.7	41.8	13.4	24.2	....	.8	1.270
Pork sides, edible portion	....	34.4	9.1	55.3	....	.5	2.505
Pork sides, total	11.5	30.4	8.0	49.0	....	.5	2.215
Chicken, broilers, edible portion	....	74.8	21.5	2.5	....	1.1	505
Chicken, broilers, total	41.6	43.7	12.8	1.4	....	.7	295
Turkey, edible portion	....	55.5	21.1	22.9	....	1.0	1.360
Turkey, total	22.7	42.4	16.1	18.4	....	.8	1.075
Black bass, edible portion	....	76.7	20.6	1.7	....	1.2	455
Black bass, total	54.8	34.6	9.3	.8	....	.5	205
Blue fish, edible portion	....	78.5	19.4	1.2	....	1.3	410
Blue fish, total	48.6	40.3	10.0	.6	....	.7	210
Flounder, edible portion	....	84.2	14.2	.6	....	1.3	290
Flounder, total	61.5	32.6	5.4	.3	....	.5	115
Lobsters	....	77.8	18.4	1.1	.5	2.5	390
Oysters	....	83.4	8.8	2.4	3.9	1.5	335

Green Vegetables.	Water.	Protein.	Fat.	Carbohydrates.	Ash or Mineral Salt.	Fuel Value per lb.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Calories.
Cabbage	91.5	1.6	.3	5.6	1.0	145
Celery	94.5	1.1	.1	3.3	1.0	85
Sun-cooked corn	15.5	12.5	5.0	66.0	1.0	1.150
Cucumbers	95.4	.8	.8	3.1	.5	80
Lettuce	94.7	1.2	.3	2.9	.9	90
Onions, fresh	87.6	1.6	.3	9.9	.6	225
Potatoes, fresh	78.3	2.2	.1	18.4	1.0	385
Potatoes, sweet	69.0	1.8	.7	27.4	1.1	570
Radishes	91.8	1.3	.1	5.8	1.0	135
Spinach	92.3	2.1	.3	3.2	2.1	110
Tomatoes	94.3	.9	.4	3.9	.5	105
Turnips	89.6	1.3	.2	8.1	.8	185
Artichokes	79.5	2.6	.2	16.7	1.0	365
Olives, green	58.0	1.1	27.6	11.6	1.7	1.400
Olives, ripe	64.7	1.7	25.9	4.3	3.4	1.205

Dried Fruits.	Water.	Protein.	Fat.	Carbohydrates.	Ash or Mineral Salt.	Fuel Value per lb.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Calories.
Dates	15.4	2.1	2.8	78.4	1.3	1.615
Figs	18.8	4.3	.3	74.2	2.4	1.475
Prunes	22.3	2.1	....	73.3	2.3	1.400
Raisins	14.6	2.6	3.3	76.1	3.4	1.605
Apples	28.1	1.6	2.2	66.1	2.0	1.350
Apricots	29.4	4.7	1.0	62.5	2.4	1.290

Dairy Products.	Water.	Protein.	Fat.	Carbohydrates.	Ash or Mineral Salt.	Fuel Value per lb.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Calories.
Eggs	73.7	13.4	10.5	....	1.0	720
Butter	11.0	1.0	85.0	....	3.0	3.605
Buttermilk	91.0	3.0	.5	4.8	.7	165
Cheese, American	31.6	28.8	35.9	.3	3.4	2.055
Cheese, cottage	72.0	20.9	1.0	4.3	1.8	510
Cheese, cream	34.2	25.9	33.7	2.4	3.8	1.950
Cream	74.0	2.5	18.5	4.5	.5	910
Milk, skimmed	90.5	3.4	.3	5.1	.7	170
Milk, whole	87.0	3.3	4.0	5.0	.7	325

Fresh Fruits and Berries.	Water.	Protein.	Fat.	Carbohydrates.	Ash or Mineral Salt.	Fuel Value per lb.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Calories.
Apples	84.6	.4	.5	14.2	.3	290
Apricots	85.0	1.1	....	13.4	.5	270
Bananas, yellow	75.3	1.3	.6	22.0	.8	460
Blackberries	86.3	1.3	1.0	10.9	.5	270
Cherries	80.9	1.0	.8	16.7	.6	365
Currants	85.0	1.5	....	12.8	.7	265
Figs	79.1	1.5	....	18.8	.6	380
Grapes	77.4	1.3	1.6	19.2	.5	450
Huckleberries	81.9	.6	.6	16.6	.3	345
Lemons	89.3	1.0	.7	8.5	.5	205
Muskmelons	89.5	.6	....	9.3	.6	185
Nectarines	82.9	.6	....	15.9	.6	305
Oranges	86.9	.8	.2	11.6	.5	240
Pears	84.4	.6	.5	14.1	.4	295
Persimmons	66.1	.8	.7	31.5	.9	630
Pineapple	89.3	.4	.3	9.7	.3	200
Plums	78.4	1.0	....	20.1	.5	395
Prunes	79.6	.9	....	18.9	.6	370
Raspberries	84.1	1.7	1.0	12.6	.6	310
Strawberries	90.4	1.0	.6	7.4	.6	180
Watermelons	92.4	.4	.2	6.7	.3	140

Nuts, Shelled.	Water.	Protein.	Fat.	Carbohydrates.	Ash or Mineral Salt.	Fuel Value per lb.
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Calories.
Almonds	4.8	21.0	54.9	17.3	2.0	3.030
Brazil nuts	5.3	17.0	66.8	7.0	3.9	3.265
Butternuts	4.4	27.9	61.2	3.5	2.9	3.165
Chestnuts, fresh	45.0	6.2	5.4	42.1	1.3	1.125
Cocoanuts	14.1	5.7	50.6	27.9	1.7	2.760
Filberts	3.7	15.6	65.3	13.0	2.4	3.290
Hickory nuts	3.7	15.4	67.4	11.4	2.1	3.345
Peanuts	9.2	25.8	38.6	24.4	2.0	2.560
Pecans	2.7	9.6	70.5	15.3	1.9	3.435
Pignolias	6.4	33.9	49.4	6.9	3.4	2.845
Pistachios	4.2	22.3	54.0	16.3	3.2	2.995
Walnuts, English	2.5	18.4	64.4	13.0	1.7	3.300
Walnuts, black	2.5	27.6	56.3	11.7	1.9	3.105

"In small diets it is said that thorough mastication and insalivation aid in the more complete utilization of the food, and render possible greater economy, so that body weight and nitrogen equilibrium are both maintained on an exceptionally small amount of food. This principle was worked out by Mr. Horace Fletcher on himself, in an attempt to restore his health to a normal condition. Deliberation in eating, necessitated by the habit of thorough insalivation, results in the occurrence of satiety on the ingestion of small quantities of food; hence all excess of food is avoided."—Chittenden.

Many of the experimental diets previously referred to, extending over periods of seven days to twenty-one days, are of little value. Many of these experiments were conducted upon men of thirty years of age and under, and did not extend to all classes of workers.

In the work of Prof. Chittenden there is no evidence as to the quantity of water taken daily, whether the subject smoked or chewed tobacco, and nothing about beer or alcoholics.

"Many writers on food and nutrition are in the habit of speaking of the oils and fats as hydrocarbons. This term can be applied properly only to compounds which contain nothing but the two elements—hydrogen and carbon. Without exception every kind of oil, fat, or wax, whether natural or vegetable, contains oxygen as well as the two elements just named. This incorrect usage of the term hydrocarbon is, moreover, peculiarly unfortunate since of the innumerable true hydrocarbons *not* a single one can be ranked as a nutrient, or as capable of being oxidized in the human body."—Church.

"A mixed meat diet is natural and most suitable to man, because vegetable foods are more bulky, more irritating and less assimilable; moreover, animal foodstuffs produce more heat. To achieve a favorable result in absorption a reasonable combination of animal and vegetable foodstuffs is essential. For all healthy and for most sick persons a mixed diet is to be recommended."—L. Kuttner.

"What to take at breakfast? If you eat toast, chew it slowly. Do not dip it into coffee, tea, or milk. Bread and milk, oatmeal porridge? No! Why not? Because, first, they are slippery foods; they slide down into the stomach before the saliva contained in the mouth has had time to digest them. It then requires a strong stomach to tolerate such food until it is passed on to the intestines."—Alderson.

Bread poultices are not suited to a weak stomach internally!

"Efficient cooking is very necessary for efficient digestion. Is any indigestion due to mechanical faults in the mouth—that is, to faulty mastication? It is necessary for food to be divided into small pieces for the purpose of entering the mouth comfortably, and to supplement mastication, it being necessary for particles of food to be finely divided in order that the secretions of the mouth, stomach, etc., may be better able to act on the substances swallowed (chemical action). Are your teeth in good order? If not, go to a dentist and have them attended to. Having your teeth in good order, be very careful not to bolt your food; use your teeth for the object for which they have been provided. Masticate well and slowly, thus finely dividing the articles of food, allowing the saliva in your mouth the time and the chance of acting chemically on the food."—Alderson.

The beginning of ill-health dates from the use of semi-solid and liquid foods by the adult. If teeth are not exercised their sockets become more or less useless and the teeth begin to loosen. The stomach having nothing to do begins to fail in its duty, the secretion of gastric juice is not sufficient and the whole line of symptoms, weak stomach, intestinal troubles, faulty digestion, from mouth to elimination, begin. The first duty, the first lesson in the doctrine of health, is to teach your patient the proper method of feeding; the hygiene of the mouth as well as that of the whole body. Caries is largely a question of environment, and teeth are not immune when surrounded by filth added to failure in their proper exercise. The consequences of using improper foods—foods not suitable for mastication—are loose teeth, carious teeth, suppuration of the gums, atrophy of the muscles of the stomach and bowels, and a train of digestive disorders which induce neurasthenia, dimness of vision and loss of ability to excrete through the skin, kidneys, and other emunctories.

In conclusion, living is a dangerous occupation any way we look at it. All sorts of things to eat which we buy at the stores are adulterated; the meat at the butchers' contains formaldehyde or ptomaines, the vegetables at the market are stale and suggest colic. "Now we read that our own tomatoes are liable to poison us if pickled too green, and if we salt them we are told that people are poisoned with sodium chloride! Maybe, after all, it is better to be a beast, or bird, or a fish, and not know about such things."

New Composition for Tinning and Soldering.—A patent recently taken out by Herr Kuppers in Germany covers a compound formed of zinc chloride and ammonium chloride, which are mixed with zinc oxide, in the proportion of one part of the zinc salt with two parts of the ammonium salt, although the proportions are not absolute. The zinc oxide acts as a flux, though it participates in the chemical reaction at the time of its application. By heating, a substance is obtained having the appearance of fused colophony. The temperature used is 140 deg. to 300 deg. C. The product is left to solidify. If it is brought in contact with water, it acquires an unctuous consistency.

ELECTRICAL NOTES.

The Stassano Electrometallurgic Process.—The Stassano electric oven, as originally constructed, was in reality a small blast furnace, in which the charge of ferruginous mixture was heated by an electric arc; and which had a lining of graphite. But as the fused metal dissolved the latter, the iron obtained had at least 2 per cent of carbon. The inventor has, therefore, replaced the graphite with magnesia. After a series of improvements the present model has the form of a Martin oven, and is heated by means of three arcs, which do not come into direct contact with the ore. The mixture is made according to the original analyses and tests, and consists of ground ore concentrated by magnetic sorting, and of charcoal in a preparation depending on the composition of the ore and the percentage of carbon in the metal to be obtained. Tar is added to the mixture, and it is made into balls 5 or 6 centimeters in diameter. It is necessary to take account of the percentage of carbon in the tar for obtaining an iron of determined carbon percentage. Iron can be obtained of a purity reaching 99.7 per cent. However, the final metal contains from 0.3 to 0.6 per cent of sulphur, and consequently cannot be used for the construction of steam engines. But it is free from manganese, and is suitable for the construction of dynamos.—From the Italian of Virginio Lucchini in the Chimica Industriale.

The advantages of a motor-driven shop over a belt-driven one are now so universally accepted that no argument is necessary. The electric motor presents the opportunity of obtaining the close variations in speed that are so conducive to economy, and there are many different systems which will give, more or less accurately, the speed changes required. Until quite recently the multi-voltage system of control was undoubtedly the best, but owing to the great improvement or rather specialization of motors this system may probably be replaced entirely by the use of field-controlled motors giving wide variations of speed. Although many engineers approve the use of the motor, yet they restrict it to the larger tools; but if it holds good for the larger tools, why not also for the smaller? Do not exactly the same arguments hold? The value of the introduction of the motor was the reduction in the cost of labor. If any tool is driven by use of belt-driven cone pulleys, what difference does it make in the output of that machine whether the countershaft is belt driven or motor driven? None whatever. It may readily be proved that for any tool on which variation in speed is required, the installation of an individual motor drive with 10 per cent speed increments will be an economical investment. The time is coming when practically every metal-working tool, where speed changes or changes in material are required, will be, in an up-to-date machine shop, equipped with its own individual motor and at practically the price of the present tools.

Electro-Magnetic Balance for Testing the Properties of Iron and Steels.—In a paper on electro-magnetic balances, published by the Revue de Metallurgie, M. De Kryloff emphasizes the necessity of testing the final products in many cases where a good metal, worked irregularly, may produce results unsuitable for the purposes for which it is designed. Present exigencies are such that many parts of ordnance and weapons must be tested when finished, as the tempering of firelocks, sword blades, projectiles, and other pieces.

Among the tests for estimating the tempering of finished pieces, he regards the common use of files and of pencils of steel of determined hardness, as giving only coarse results not responding to present needs. The electro-magnetic test has not the same defects, and offers the possibility of determining exactly and rapidly the qualities of the articles tested, without regard to their exterior form and surfaces.

He describes the magnetic balance of Prof. Hughes and the electro-magnetic balance, both of which have been installed at the Imperial Firearms Works at Toula, Russia. The latter, which he has used personally, allows, he states, of investigating different questions that arise concerning firearms and of determining the degrees of tempering and of annealing of the pieces that enter into their manufacture. The electro-magnetic test, as adopted at Toula, permits of classifying iron and steel according to their aptitude for tempering.

Electro-Chemical Division of Carbon Chloride into Chlorine, Carbon, and Other Carbon Chlorides.—When the electric arc is made to act on carbon chloride in a liquid or vaporous state, or on a mixture of different carbon chlorides in either of these conditions, gaseous chlorine is liberated, with simultaneous formation of carbon chlorides less rich in chlorine, and of very finely divided carbon. On this fact the Société Anonyme l'Etudes Electro-Chimiques has founded a process for decomposing carbon chlorides by means of the electric arc into gaseous chlorine and various products. The application will be apparent from an example, e. g.: A current of carbon tetra-chloride (liquid or vapor) is turned into a receiver of a material unaffected by chlorine (glass, porcelain, etc.) in which there are two electrodes not subject, or very slightly subject, to the action of chlorine (for instance, iridized platinum). The electric arc is projected between the electrodes. Under the influence of the arc chlorine is set free and at the same time the liquid becomes charged with divided carbon, or the latter is deposited with small drops of the condensed liquid, if the operation has been conducted with a current of carbon chloride in the state of vapor. The chlorine is cooled and filtered to separate out the carbon and conveyed back into the apparatus, and so on. After a certain number of passages through the electric arc the filtered liquids of the divided carbon are enriched with complex carbon chlorides, and a new quantity of carbon tetra-chloride is added. In this way all the tetra-chloride is gradually converted into chlorine and carbon. Instead of operating on pure carbon tetra-chloride, other carbon chlorides or mixtures of various chlorides may be substituted. For electric energy, either the direct or the alternating current may be employed. In both cases high tensions are necessary, on account of the great insulating resistance of carbon chlorides.

ENGINEERING NOTES.

An efficient tool-room is a requisite of a good shop. In it the tools should be kept in some good system, and should be kept always in the best of condition. The machines in this department should be high-class, otherwise their imperfections will be reproduced in the tools. In the larger shops it is the duty of the tool-room not only to see that certain tools are on hand for doing the work, but to see what jigs or other fixtures could be made to cheapen production, and to consider in general the best way to handle any special job.

Any experienced bridge engineer is competent to decide upon the proper design of a structure, wherein utility and economy are the only considerations, but not if the structure requires æsthetic treatment, as engineers are generally deficient in æsthetic training. In the design of a structure of monumental character, the engineer should co-operate with a competent architect, who should be a true artist and not merely a decorator. The best results can only be obtained by a competition, such as is the usual practice with other monumental structures, the jury of selection to be composed of engineers and architects. This method was adopted in the selection of designs for the proposed Memorial Bridge and the Red Creek Bridge at Washington, and has proved very satisfactory. The Washington Bridge, in New York city, and the Cambridge Bridge, at Boston (nearly completed), are good examples of monumental city bridges.

The experiments that have been carried out with oil fuel in three of the "Majestic" class of warships in the British Channel fleet proved successful when the oil was used in conjunction with certain qualities of soft coal, especially for auxiliary steaming purposes. The type of burner employed was of a special design, evolved from the results of the tests. It was found that by spraying crude petroleum under great pressure upon a thin fire of ordinary coal, high calorific powers can be obtained and steam can be well maintained thereby. Difficulty is still being encountered however in the regulation of combustion in order to overcome the dense noxious fumes emitted. Oil is found to be highly efficient when cruising at economic speed, but at high speeds it is unsatisfactory and inferior to the Welsh steam coal. That the Admiralty, however, intend to utilize liquid fuel to a considerable extent is shown by the measures being adopted by them for the storage of the petroleum at the naval depots. Four huge tanks have been constructed at the Portland naval base, and at Gibraltar twenty-three tanks are being constructed. Each tank will have a capacity of 1,640,000 gallons thereby enabling a supply of 37,720,000 gallons to be held in reserve.

Modern large engines have attained high organic efficiency owing to the proportional reduction of their weight and the finish of their construction. Double-acting engines are usually made with a weight of at least 100 kilogrammes per horse-power (220½ pounds). It is admitted that Otto cycle double-acting engines attain 90 to 92 per cent mechanical efficiency, whereas an output of only 75 to 80 per cent was attained by two-cycle engines. This waste, being due to the work absorbed by the air-pump and by the gas-pump, cannot, however, deteriorate the value of the magnificent engines, of which the Oechelhäuser and the Koerting are classical types possessing their own advantages. Double-acting Otto cycle engines attain a thermal efficiency of 28 to 30 per cent relatively to the effective work, i. e., the horse-power hour is attained with about 2,200 calories (8,729 B.T.U.). This consumption converted into the volume of the different gases used industrially would be as follows:

Coke-oven gas 585 liters (20.7 cubic feet).
Mond producer-gas 1,760 liters (62.2 cubic feet).
Anthracite producer-gas 1,850 liters (65.4 cubic feet).
Blast-furnace gas 2,500 liters (88.3 cubic feet).

Fifteen years ago there was a tendency to belittle technical information gained in schools. It was claimed that too much science was being taught, and that the young men taking these courses were being filled up with a lot of miscellaneous information which was labeled applied science, but was really tommy rot. That period of distress is fortunately now past. Thanks to the great improvement that has taken place in technical instruction, the young man who gets through such a school without having a pretty good idea of the basic principles on which engineering rests is slick enough to be good timber for an old-style insurance president. Unfortunately, it is not at all improbable that the pendulum has been swinging too far in the other direction lately, and that brash youth laden with good theory but somewhat shy of experience is confident that he can design and construct anything desired. It is hardly possible to explain some of the strange things done in the name of reinforced concrete and the crimes perpetrated under the name of sewage disposal except on the supposition that there has been some youthful slip in making the theory fit the problem.—Engineering Record.

SCIENCE NOTES.

Free ammonia contained in a water may be rapidly removed by plant life or be changed into nitrites and nitrates, and then be absorbed by algal forms, the plant life thus stimulated again adding to the water undecomposed nitrogenous compounds. Consequently, while a low ratio as 1 to 5 between the nitrogen of the free ammonia and the nitrogen of the albuminoid ammonia indicates pollution, the reverse cannot be said to be a strong indication that the water is a normal water, one containing only vegetable matter.

The microbe of leprosy was discovered some time ago in Sweden. Dr. Nicolle, in a communication to the Académie des Sciences, described the results obtained from inoculating two baboons with the virus, as soon as possible after the ablation of the human leprous tumor. The inoculation was effected in different ways in order to find the most favorable method; first the injection was made subcutaneously, then in the mucous membrane of the eye, in the mucous membrane of the nose, in front of the ear and in the pavilion. The lesions soon healed and for two days no result was manifest; then a swelling appeared in front of the ear and within the pavilion. When this nodosity attained the size of a hazel nut, it was removed and a section examined under the microscope presented the appearance of leprous structure. Large cells filled with bacilli were not found, but there were cells containing several of these. It is supposed that the tumor, on thoroughly ripening, would more closely resemble that of leprosy.

Scientific utilization of the Eiffel Tower has been undertaken for the purpose of researches on twilight. At the time of the summer solstice in Paris, the night is not complete, the sun descending less than 18 degrees below the horizon. Under these conditions the crepuscular light is visible from the setting of the sun in the northwest to its rising in the northeast. At midnight it is due north, and then a luminous arc several degrees in height can be observed. MM. Pouchet and Quisset were the first to succeed in photographing this feeble illumination from the top of the Eiffel Tower. Several negatives were obtained, indisputably exhibiting the solar light. The late esteemed physicist, M. Cornu, in presenting an account of his investigations to the Astronomical Society of France, emphasized the utility of undertaking photometric researches for the purpose of tracing the isophotic curves of the twilight. M. Touchet has since constructed a new photometer with direct vision for the study of slight intensities, and this apparatus he has utilized at the Eiffel Tower in collaboration with M. Senoque. The Eiffel Tower may still be the means of rendering great service in the succession of scientific investigation occurring from day to day.

Analysis of the Carbonic Oxide in the Air.—If a small quantity of carbonic oxide is added to air free from this gas, and the mixture is passed over heated iodic acid, all the carbonic oxide can be recovered. The French scientists Albert Levy and Pecoul have utilized this fact in constructing apparatus allowing a person, though unfamiliar with laboratory processes, to determine exactly and easily the proportion of carbonic oxide contained in atmospheric air. The apparatus is kept in a compact case. It is composed essentially of a reservoir performing the office of aspirator, of an iodic acid tube capable of being heated to 60 or 80 deg. C. by means of an alcohol lamp, and of a tube containing chloroform, into which the iodine set free escapes. Under the action of the iodine the liquid becomes colored a more or less brilliant rose, according to the quantity of iodine. By standardizing mixtures of air and carbonic oxide, it is possible to prepare comparison tubes. If afterward atmospheric pressure is tested, the percentage is determined by comparing the color of the test tubes with the standard tubes; identical percentages can be thus calculated. This simple and practical process allows, it is said, the determination of quantities as low as 3/100,000. The authors have found no trace of carbonic oxide in the atmosphere of Paris, notwithstanding the enormous volume of gaseous combustion occurring in the city.

Capock and Its Uses.—Few readers are familiar with this product, which is, however, employed in large quantities in certain countries. For example, Holland imported in 1902 more than two million pounds. In France the capock is almost unknown, but in various maritime communities and in the English and German navies it is utilized for the manufacture of life-saving apparatus. Capock is the filamentous and downy envelope of the fruits of certain trees belonging to the family of the bamboos, and designated in the Dutch Indies under the name of the "false cotton tree." When the capsule of the fruit is open, a mass of yellowish brown silky filaments are found therein; these envelop the tender part, the pulp of the fruit, like the stigmas of maize. This filamentous material is very light, and scarcely absorbs water. After a maceration of several months its weight remains nearly the same, and because of this property it can be utilized like cork. A girdle of less than a pound of capock is sufficient to support on the surface of the water a man of ordinary stature. In France MM. Beille and Lemaire are advocating the introduction of this product in medico-surgical therapeutics as a substitute for wadding or cotton for bandages and compresses in dressings, thus sheltering the wound from all aqueous inhibition. Barracks and hospitals, it is supposed, will be benefited by its introduction. The cultivation of this variety of bamboo might be promoted in eastern colonies, so as to bring down the price, which is still a little too high for hospital use.

TRADE NOTES AND FORMULÆ.

To Polish Ivory.—First rub with a piece of linen soaked with a paste made of Armenian bole and oleic acid. Wash with Marseilles soap, dry, rub with a chamois skin, and, finally, render it bright with an old piece of silk. If the ivory is scratched, it may be smoothed by means of English red stuff on a cloth, or even with a piece of glass if the scratches are rather deep. In the hollow parts of ivory objects the paste can be made to penetrate by means of an old tooth-brush.—Nouvelles Scientifiques.

Preparation for Cleaning Marble, Furniture, and Metals, Especially Copper.—This preparation is patented in France under the name of "La Favorite," and is claimed to give very quickly perfect brilliancy, persisting without soiling either the hand or the articles, and without leaving any odor of copper. The following is the composition for 100 grammes of the product: wax, 2.4 grammes; oil of turpentine, 9.4 grammes; acetic acid, 42 grammes; citric acid, 42 grammes; white soap, 42 grammes.

Industrial Preparation of Vaselines and Mineral Lubricating Oils.—A process has been introduced for producing industrial vaselines and mineral oils for lubrication, based on the treatment of naphthas, petroleums, and similar hydrocarbides, by means of chlorine or mixtures of chlorides and hypochlorides, known under the name of decoloring chlorides. Mix and stir thoroughly 1,000 grammes of naphtha of about 908 density, 55 grammes of chloride of lime, and 500 grammes of water. Decant and wash.—Revue des Produits Chimiques.

New Explosive.—A new explosive has been introduced in France by M. Berge, claimed to be specially applicable to mines and quarries. It is composed of chlorate of potash, 1 kilogramme; chromate of potash, 0.1 kilogramme; sugar, 0.45 kilogramme; yellow wax, 0.09 kilogramme. The proportions indicated may vary within certain limits, according to the force desired. For the preparation, the chlorate and the chromate of potash, as well as the sugar, are ground separately and very finely, and sifted so that the grains of the different substances may have the same size. At first any two of the substances are mixed as thoroughly as possible, then the third is added. The yellow wax, cut in small pieces, is finally added, and all the substances are worked together to produce a homogeneous product. The sugar may be replaced with charcoal or any other combustible body. For commercial needs, the compound may be colored with any inert matter, also pulverized.

Red Patina.—The following is a new method of making a red patina, the so-called blood-bronze, on copper and copper alloys:

The metallic object is first made red hot, whereby it becomes covered with a coating consisting of cupric oxide on the surface and cuprous oxide beneath. After cooling, it is worked upon with a polishing plate until the black cupric oxide coating is removed and the cuprous oxide appears. The metal now shows an intense red color, with a considerable degree of luster, both of which are so permanent that it can be treated with chemicals, such as blue vitriol, for instance, without being in the least affected.

If it is desired to produce a marbled surface, instead of an even red color, borax or some chemical having a similar action is sprinkled upon the metal during the process of heating. On the places covered by the borax, oxidation is prevented, and after polishing, spots of the original metallic color will appear in the red surface. These can be colored by well-known processes, so as to give the desired marbled appearance.—Neueste Erfahrungen und Erfindungen.

Preparation of Paper with Ferro-Prussiate.—The Centralblatt der Bauverwaltung gives directions for the aniline process of preparing sensitive paper, employed with success by the Prussian and Hessian railway administrations. The ordinary paper on reels is used for the purpose, and sensitized as follows:

Two hundred and fifty parts, by weight, of potassium bichromate, in powder form, are dissolved in water; the solution should be completely saturated; 10 parts of concentrated sulphuric acid, 10 parts of alcohol (962), and 30 parts of phosphoric acid, are added successively, and the whole stirred together. The solution is spread over the paper with a sponge. The curtains of the room where the work is done should be drawn, but it is not necessary to have the room perfectly dark, or to work by a red light. The drying of the paper, in the same place, takes about ten minutes, after which the tracing to be reproduced and the paper are placed in a frame, as usual, and exposed to daylight. On a sunny day, an exposure of 35 seconds is enough; in cloudy weather, 60 to 70 seconds; on a very dark day, as much as five minutes.

After exposure, the paper is fixed by suspending it for twenty minutes upon a bar in a closed wooden box, on the bottom of which are laid some sheets of blotting-paper, sprinkled with 40 drops of benzine and 20 of crude aniline oil. The vapors given off will bring out the design. Several impressions may be taken at the same time.

For fixing, the crude aniline oil is to be used (anilinum purum), not the refined (purissimum), for the reason that the former alone contains the substances necessary for the operation. The reproduced design is placed in water for a few minutes, and hung up to dry.

The quantities given for the solution are sufficient for about 10 square meters of paper, the cost of the chemical materials about 12 cents. The paper is cheaper than the commercial paper, and keeps better.

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